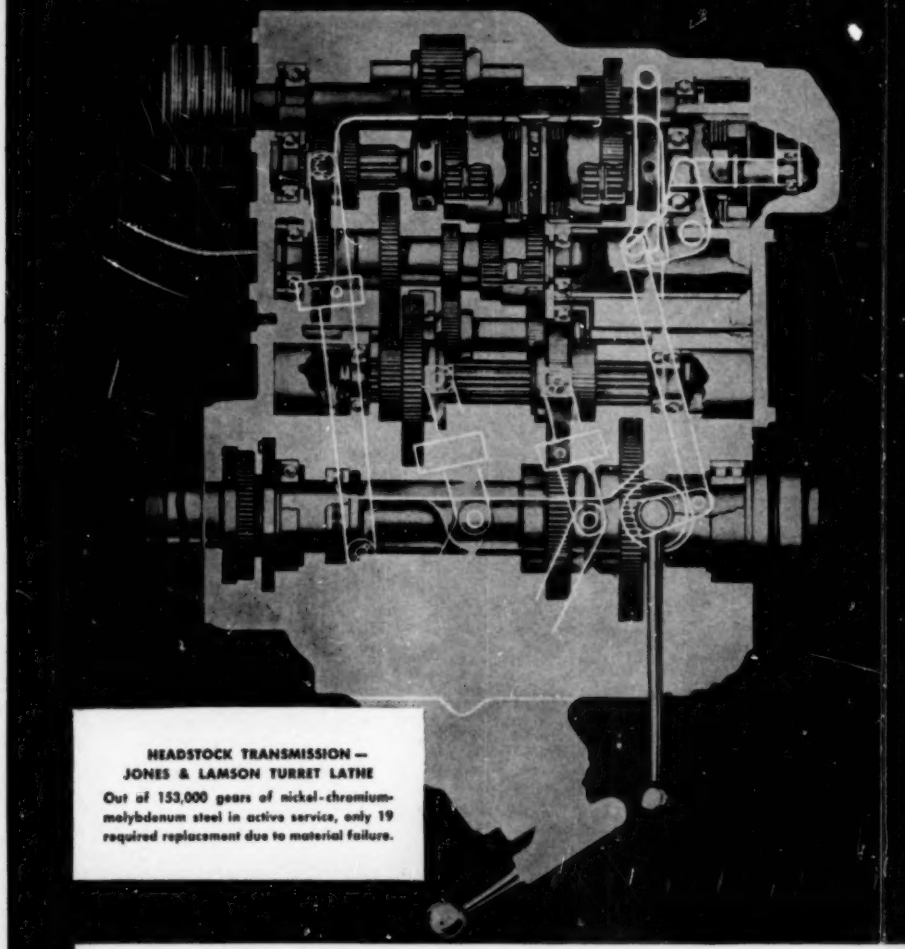
CAN YOUR EQUIPMENT MATCH THIS AMAZING RECORD?



HEADSTOCK TRANSMISSION — JONES & LAMSON TURRET LATHE

Out of 153,000 gears of nickel-chromium-molybdenum steel in active service, only 19 required replacement due to material failure.

A study of replacements during a 12-month period of World War II revealed an astonishing performance record for nickel-chromium-molybdenum steel gears used in the headstocks of Jones & Lamson Ram Type Turret Lathes. In spite of frequent overloads and punishment due to inexperienced operators, failures were cut to less than 00.02%. Because of this remarkable record, Jones & Lamson Machine Co., Springfield, Vt., continues to specify these shafts and gears in "872" and "874" nickel-chromium-molybdenum steels produced by Carpenter Steel Company, Reading, Pa.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

VOLUME 21 — PRODUCT ENGINEERING — NUMBER 4

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Publication Office: 99-129 North Broadway, Albany 1, N. Y. Return postage guaranteed. **Published Monthly** by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder; Curtis W. McGraw, President; Willard Chevalier, Executive Vice-President; Eugene Duffield, Senior Vice-President, Publications Division; Nelson Bond, Vice-President and Director of Advertising; Joseph A. Gerardi, Secretary and Treasurer; J. E. Blackburn, Jr., Vice-President and Director of Circulation. **Correspondence About Subscriptions** should be addressed to Director of Circulation, Product Engineering, 330 W. 42nd St., New York 18. Allow at least 10 days for change of address. Indicate position and company connection on all subscription orders.

Subscription Rates: Single copies 75c. United States and possessions, $6 for one year, $9 for two years, $12 for three years; Canada, $7 for one year, $11 for two years, $14 for three years; Latin American countries, $10 for one year, $16 for two years, $20 for three years; all other countries, $15 for one year, $25 for two years, $30 for three years.
Editorial and Executive Offices: 330 W. 42nd St., New York 18. Cable address: "McGraw-Hill." N. Y.
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Entered as second-class matter Aug. 31, 1950, at Post Office, Albany, N. Y., under act of Mar. 3, 1879. Printed in U. S. A.
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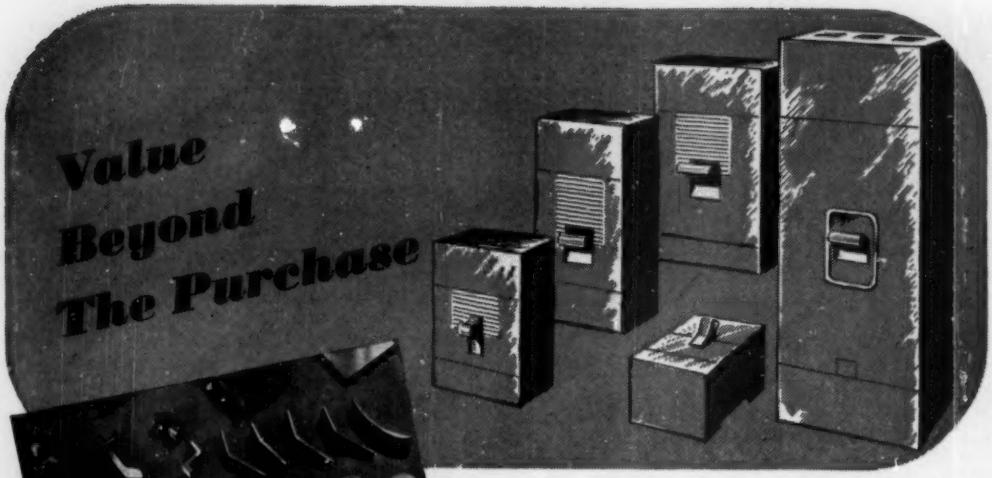
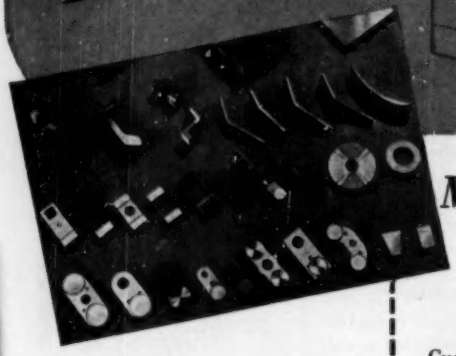




Mallory Contact Development Anticipates Customer Needs!

Customers' contact problems are solved rapidly and effectively due to Mallory's precise attention to every detail of design, material and production.

A manufacturer of small industrial circuit breakers recently asked Mallory to study his contact assembly . . . with an eye to reducing costs. Investigation proved that new Mallory equipment coupled with unique Mallory production techniques would eliminate certain expensive finishing operations. As a result, the problem was solved in rapid-fire order . . . and the contacts delivered at a price that is 21% less than the customer previously had been paying.

That's value beyond the purchase!

Mallory contact know-how is at your disposal. What Mallory has done for others can be done for you!

In Canada, made and sold by Johnson Matthey & Mallory, Ltd., 110 Industry St., Toronto 15, Ontario

Elkonite* Contacts

Elkonite is the trade name for a series of contact materials developed by Mallory and manufactured from metal powders. They are best known for their hardness, resistance to mechanical wear and impact, resistance to erosion by arcing, and resistance to sticking.

Elkonite contacts are made by the only method which permits the combining of the desirable features of basic metals which cannot be alloyed. By this means, the high melting points of tungsten, molybdenum, or their carbides, can be combined with the current-carrying ability of silver and copper.

Electrical Contacts and Contact Assemblies

*Reg. U. S. Pat. Off.

P. R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

SERVING INDUSTRY WITH

Capacitors	Contacts
Controls	Resistors
Rectifiers	Vibrators
Special Switches	Power Supplies

Resistance Welding Materials

Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

Metallic Materials

ERRATUM! Pulled a boner in the February issue, page 3, second item regarding NODULAR GRAPHITE. While Meehanite castings are heat-treatable and can be flame hardened, main point is that their superior characteristics result from metallurgical and process controls.

ATOMIC RESEARCH has shed considerable light on the behavior of polonium, the radioactive element discovered in 1898 by Madame Curie. Instead of expanding when heated to its melting point of 590 F, the lead-like metal shrinks. This phenomenon may be the result of the element's cubic crystal structure. Density is 9.4 g/cc; radioactive half-life is 138.3 days.

THE ADDITION of about 5 percent mercury to a copper-zinc-cadmium silver soldering alloy

results in a brazed joint in steel of 40,000 to 70,000 psi tensile strength. Relatively low melting range varies from 1,100 1,200 Fahrenheit.

NEW APPLICATIONS for the cobalt-base alloy, Elgiloy, that is non-corrosive and best known as a substitute for high-carbon steel watch springs, is spreading its wings into other fields. Easily machined, soldered, welded or brazed, material is appearing as instrument pivots, constant-deflection tension and compression springs, pen nibs, wrist bands, cutlery, spring washers, fire fighting equipment and other products.

PURE COPPER solidifies at a temperature 113 deg below that of the standard grade, 1980 F. Similar changes have been detected in pure Au, Ag, Hg, Ga and other metals. Removal of 0.001 percent N from soft magnetic iron can result in a 30-fold jump in permeability; addition of an equally small amount of S makes chrome-molybdenum alloys super-brittle.

THREE FILMS of silver and magnesium fluoride are the heart of a new color filter that has possibilities for television use. Thickness of

the metallic films, applied to glass under high vacuum, determines which pure-color component of white light—red, blue, green or yellow—will pass through the filter. By varying the film's thickness in different areas on the filter face, multicolor designs can be produced.

HIGH TEMPERATURE metal-ceramic compound of chromium and aluminum melts at 3,350 F, is superior to most ceramics in resistance to thermal shock, resists oxidation to 2,200 F, and has short-time bending strength of about 15,000 psi. Rods and tubes up to 3 in. in dia can be produced. Material is also adaptable to complex shapes such as threaded bolts, racks and roller pinions, combustion heater tubes and burner tips.

Nonmetallic Materials

THE FAMILY of alkyd molding compounds has added a new member in the form of putty. This consistency permits high-speed molding operations at pressures as low as

50 psi. Lightweight hydraulic or air actuated presses can therefore turn out plastic shells molded around delicate, precisely located inserts without danger of crushing or dislodging electrical contacts, or bushings.

EXTRUDED PLASTIC PIPE for conducting processing fluids, chemicals, fumes, dust and even electrical cables is corrosion resistant and stable at temperatures from -50 to +140 F. A 3-in. dia 100-ft section of the semi-rigid pipe weighs only 90 lb, has a tensile strength of 1,400 psi and a flexural strength of 1,700 psi. Connections between 20-ft lengths are made with tightly-fitting plastic sleeves.

Continued on Page 5

A simple STOCK answer to your drive problems

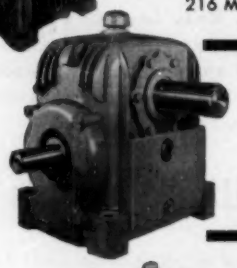
...available from stock at an amazingly low cost per horsepower

444 standardized gear sets
Over 190,000 standardized reducers
Only 58 standardized mountings

The double-enveloping principle of Cone-Drive Gears also gives you higher load capacity, longer life, less weight, greater compactness.

All parts for a given center distance—gears, mountings, bearings, housings, fan-cooling attachments and water cooling coils (for continuous, high-load operation), etc.—are standardized whether you use pinion over or under, gear shaft vertical or horizontal, single or double extended shafts, right or left hand.

192 Models; 8 Ratios (5/1 to 50/1); 2" Center Distance.....	.06 to 3 hp
192 Models; 8 Ratios (5/1 to 50/1); 2½" Center Distance.....	.1 to 5½ hp
216 Models; 9 Ratios (5/1 to 60/1); 3" Center Distance.....	.17 to 9 hp



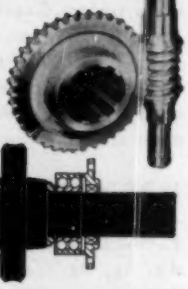
2539 Models (1421 of these may also be fan or water-cooled)
9 Ratios (5/1 to 60/1) in 4" Center Distance
10 Ratios (5/1 to 70/1) each in 5" to 12" Center Distances
8 Ratios (10/1 to 60/1) in 15" Center Distance
9 Ratios (8/1 to 60/1) in 18" Center Distance

2 to 636 hp @ 1150 rpm (HP at higher and lower input speeds approximately in proportion)

Ratios up to 4900/1 (186,250 reducer combinations) Max. Output Torque 4,000 to 244,600 in.-lbs. Input—½ to 68 hp. Water cooling available for either or both primary and secondary units. 2½" and 3" center distance primaries are special

Double-Reductions *(Std. Reducers Combined)*

STANDARDIZED GEAR SETS FROM STOCK—A size and ratio to fit most needs. .06 to 636 hp. 7 to 10 ratios in each size (5/1 to 70/1). Remarkably compact. Available with standardized interchangeable mountings with anti-friction bearings. Single or double extended pinion or gear shafts, pinion over or under, gear shaft vertical or horizontal.



Complete specifications and prices on request. Please give approximate hp range, input speeds, ratio and approximate quantities which would be required.

CONE-DRIVE GEARS
Division, Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNichols Road • Detroit 12, U.S.A.

IMPREGNATED KRAFT PAPER for sealing metal parts from corrosive atmospheres has an aluminum foil backing. Foil resists scuffing, oils, greases, mild acids and alkalis. No wax, tape or heat is needed for sealing, just a drugstore fold and a twist at the ends.

SINGLE-WRAP INSULATION cuts down waste and bulk on electric wiring connections. Extra-

thin 3/4-in. tape is highly wear resistant, takes 175-F temperatures in stride and is good for 7,000 v as a dielectric. Recommended for automotive applications where moisture, oils and acids are prevalent. Tape has stretch of 125 percent.

POLYESTER ENAMEL for magnet wires meets NEMA standards set for vinyl-acetal coatings, remains flexible at 250 F–300 percent longer than nylon and acetal, and outperforms the latter in abrasion tests. No dies are needed for maintaining uniform film thickness, the viscosity of the solution takes care of this.

KEL-F, one of the new fluorine plastics, is now being injection molded as well as compression molded. Highly dielectric, moisture resistant and stable from -320 to +375 F, material can now be applied to widespread uses in the electrical field as parts of motors, transformers, instruments and radios.

Processes

ZINC-CHROMATE PRIMERS used on aluminum and magnesium alloys have often been subject to slight porosity and moisture penetration. This loophole is now being plugged in a very simple manner – add synthetic resins to fortify the solution.

ALUMINUM SURFACES are made absorptive to coloring dyes by electrodeposited oxides. Chemical coatings are known to do a better

job, but this operation is quite often overlooked because of excessive costs. Simple, inexpensive chemical methods can now be used, the satisfactory absorptive characteristics being obtained during a final bath in a hot, aqueous solution containing ammonium compounds. Designs and lettering on the finished part are sharp and clear.

FORMABILITY of high-strength aluminum alloys is significantly improved after a resolution treatment at slightly elevated temp-

eratures. 14S, R301 and 24S are aged at 300 to 400 F for periods up to 30 min; 24S Alclad takes 10 min at 375 F. Physicals are not materially affected, but corrosion resistance is lowered. Precipitation heat-treatment restores the latter.

LARGE, COMPLEX CASTINGS are often headaches because of the high pattern costs involved. Several companies are getting around this problem by casting the part in several pieces and welding them together. The assembly is then annealed to relieve stresses.

MAGNESIUM-BASE ALLOYS, AZ63 and AZ92, can be cast by the lost-wax process, according to tests made by the Air Materiel Command. Compared to sand cast parts made of the same materials, investments exhibit slightly lower tensile strength and a considerable reduction in elongation.

Components

FLEXIBLE COUPLING about the size of a man's fist handles torque loads of 300 hp at a speed of 9,000 rpm. Eight wafer-thin disks having a hyperbolic wall section permit misalignment up to 3½ deg. 1,300 hr of testing on a single pair of disks turning at 10,000 rpm and 10-deg angularity have failed to produce any signs of fatigue.

SEEING ABILITY of photoelectric multiplier tubes has been increased six-fold through re-

design. Light pulls an electron from a metal surface and causes it to strike a charged plate, producing a shower of additional electrons. Repetition of this cycle through a series of plates results in extreme magnification of original current.

EFFICIENCY of selenium rectifiers can be raised by adding a counter-electrode of cadmium-tin. This extra element also contains small amounts of gallium, boron, cerium selenide, columbium oxide, or a metal from the alkali or alkali-earth group.

Continued on Page 7

Added attraction at the water hole

Oasis Water Coolers made by Ebco Manufacturing Co., Columbus, Ohio.

IN the bottle-type water cooler, you need a gasket to act as a seal between the bottle and the cabinet. Rubber did an acceptable job for many years, but there were problems . . . although the gasket never touches the water, a rubbery taste and odor were transmitted through the air.

To one of the leading manufacturers of electric water coolers, this complaint needed attention. The answer was a new extruded heat sealed gasket made from Geon plastic.

The new gasket has proved to be just what was needed. No odor or taste is transferred to make the water unpalatable. The gasket is impervious to oils, mildew, acids or gases. It keeps its shape and pliability under all conditions of temperature. It is non-fraying, and can be wiped clean with a damp cloth.

Other advantages of Geon polyvinyl materials are resistance to aging, weather and wear. Colors can be brilliant or delicate—and Geon can be extruded, compression or injection molded, calendered, or used as a coating.

Geon's versatility may point the way to improving or developing a product for you—sending more sales your way! We make no finished products—raw materials only. But we'll gladly help you with technical bulletins and helpful service. Write today. Address Dept. GO-2, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

See the newest Geon materials on display. Booth 130, 4th Nat'l. Plastics Exposition, Navy Pier, Chicago, Illinois, March 28-31, 1950.

B. F. Goodrich Chemical Company

A DIVISION OF THE B. F. GOODRICH COMPANY

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers

STORAGE TUBE for binary computors circuits can memorize 400 digits. Device keeps track of problems and partial answers by storing "dots" of electrostatic charges on beryllium "islands" deposited on a sheet of insulating mica within the tube. A high-voltage electron beam "writes" on the beryllium and then a low-speed beam "sprays" the target surface to prevent charges from leaking off.

COMMERCIALLY PURE titanium tubing having a minimum yield strength of 40,000 psi and a maximum ultimate of 80,000 psi is now available. Highly corrosion resistant and light in weight, tubing comes in three standard tempers in sizes ranging from 1/8 in. OD with 0.010 in. wall to 3/4 in. OD with 0.049 in. wall.

COOLING SYSTEMS in automobiles can be filtered continuously, just as the crankcase oil is – with a cartridge attachment. Water is by-passed through the unit where it is both filtered and softened. Chemicals from the replaceable element loosen scale which is trapped as it goes through the filter.

Testing

POROSITY in organic or plated coatings can be studied with a new electrographic tester. A piece of saturated filter paper is pressed on the coated metallic surface which acts as the anode of an electrolytic cell. Small amounts of the metal exposed to the paper are dissolved in the filter where they can be analyzed with chemical reagents.

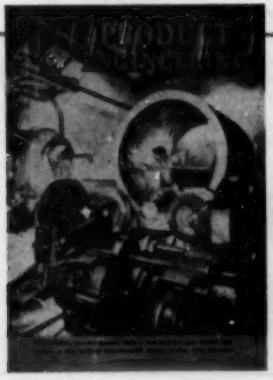
AIR SAMPLES captured from the atmosphere 18 miles above the earth are being analyzed in a cyclotron-type mass spectrometer. Gas molecules are ionized, accelerated through a magnetic field and separated according to weights ranging from 1 to 300.

LATEST TECHNIQUE for detecting flaws in dense materials, both metallic and nonmetallic, is the so-called oil-powder method. Apply penetrating oil to the surface, wipe it off after a minute's time and then dust on the detecting powder. Flaws appear as sharply defined red lines on the dull white powder background.

SHOCK TESTER, designed primarily for safety checks on live fuses, but applicable in other fields, really gives a part the "works." During a 17-min cycle, a rotating striker head drops the fuse onto a cushioned anvil 1,024 times in 962 directions.

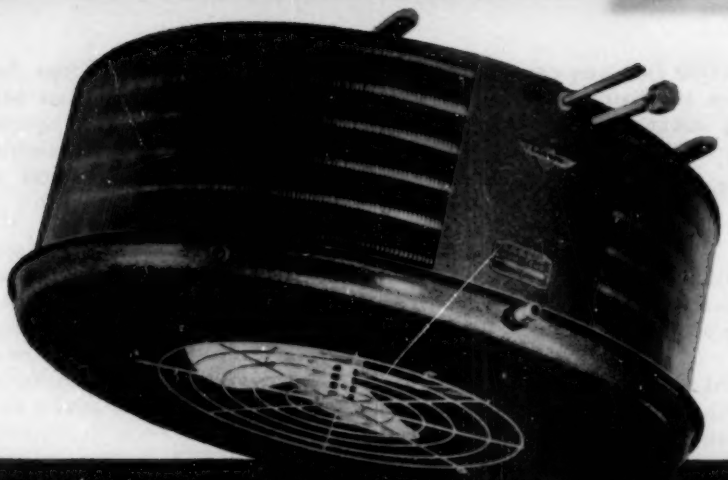
TWENTY-FIVE for the price of one! That's the number of accelerated wear tests that a special machine can make on experimental chromium plated cylinder liners while a full-scale Diesel is testing one particular liner. Wear on plated surfaces can be determined to an accuracy of ±0.00005 in. with this machine that is part of the Navy's present program for evaluating 3,861 different types of chromium.

MAGNETIC DISTURBANCES that sometimes upset delicate instruments can now be spotted down to the last 1/10 milligauss. A detector having this supersensitivity is being used in conjunction with a nonmagnetic centrifuge that will test small parts for stress defects.



THIS MONTH'S COVER

Catching all of the drama inherent in high voltage, cover artist Kent Coes gives us his water-color view of the new 2,000,000 volt General Electric X-ray machine. The Babcock and Wilcox Company uses this machine at their Barberton, Ohio, plant to inspect welded seams in steel pressure vessels. These seams are from four to seven inches thick—and they must meet the rigid requirements of the ASME Boiler code. The new unit can film an image of the internal structure of five-inch rolled steel in one minute. Using a smaller machine and a measly 1,000,000 volts the same job takes half an hour. Babcock and Wilcox built a special building to house this high voltage unit with 32 inch concrete walls for X-ray protection. The machine itself is suspended from cables from an overhead bridge crane, and has a pantograph support for stability.



COPPER AND ALUMINUM

Larkin Cross-Fin Coils Achieve Durability, Efficiency and Economy by using Revere Aluminum Coiled Sheet with Revere Copper Tube.

THE Larkin Turret Humi-Temp (shown in photo) is a forced convection unit that provides all-around temperature and humidity control. A key feature is its Larkin Cross-Fin Coil, constructed of copper tube with aluminum fins. Through the use of these two metals, Larkin Coils combine durability, efficiency and economy to a degree that could not be achieved with any one metal.

As a supplier of *both* copper-alloy and aluminum-alloy mill products, Revere is in a position to give manufacturers unusual cooperation through our Technical Advisory Service as well as through our manufacturing departments. If you are designing a product using aluminum or copper, or both, why not let Revere work out your problems with you?

A Revere Technical Advisor works with you confidentially, of course. And he can help you most when your products are still in the design stage. Call the Revere Sales Office nearest you today!

SEND FOR THIS BOOKLET! *"Revere Aluminum Alloys" describes the aluminum alloys furnished by Revere, gives you the properties of each, and shows many of the products being made from them. Write for your copy today!*

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

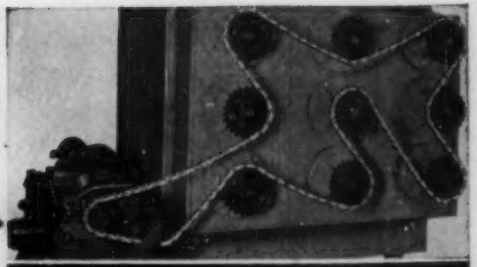
230 Park Avenue, New York 17, New York

• • •

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.
Sales Offices in Principal Cities, Distributors Everywhere.

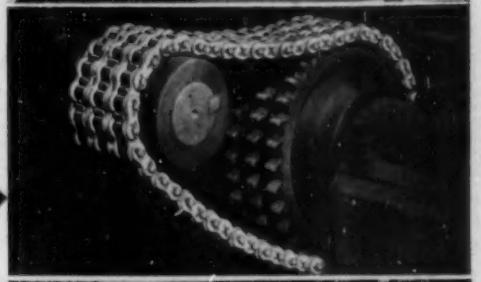
FLEXIBLE!

Link-Belt Precision Steel Roller Chain is flexible; a series of linked rollers that form a flowing highway of power.



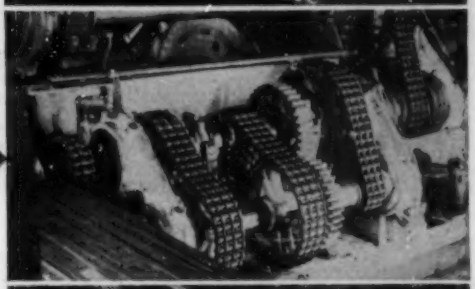
POWERFUL!

Link-Belt Precision Steel Roller Chain can be applied to small fractional horsepower machines or to units involving more than a thousand horsepower.



SHORT CENTERS!

Link-Belt Precision Steel Roller Chain can be used on short centers at high ratios. Adapted to withstand heavy starting loads and severe shock.



LONG CENTERS!

Link-Belt Precision Steel Roller Chain is adapted to coordinate motion of widely separated shafts, affording positive operations.

RELIABLE!

Made by Link-Belt—your guarantee of superior construction and proper design.

LINK-BELT COMPANY Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities. 11,473-C

LINK-BELT

ROLLER CHAINS & SPROCKETS

GRAPHITAR ROTOR

(CARBON-GRAPHITE)

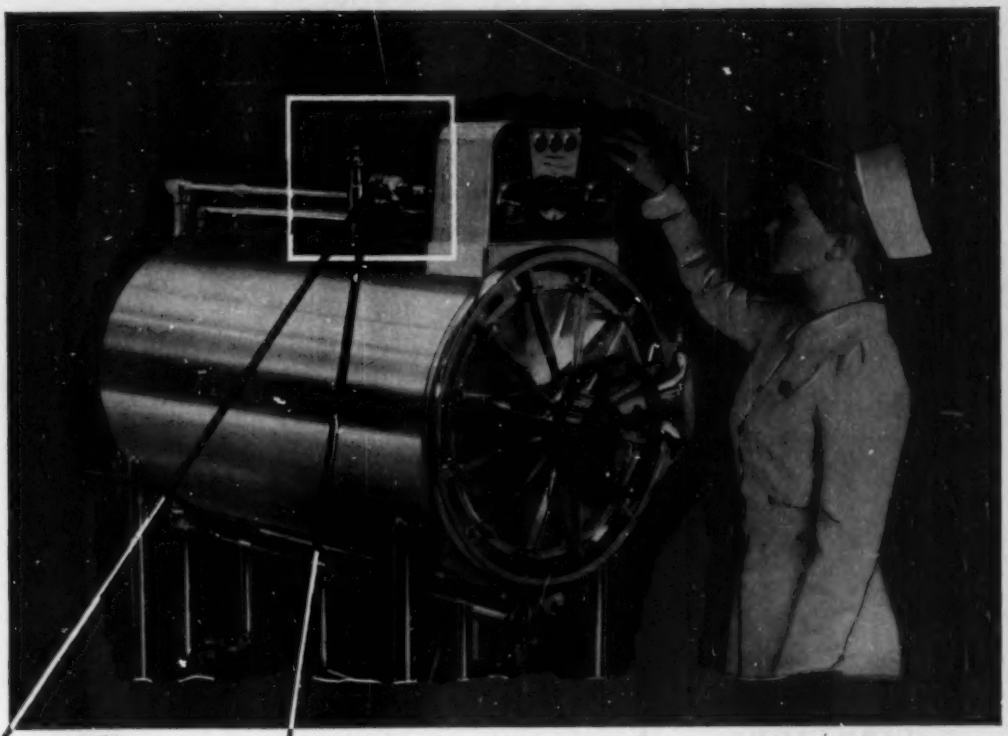
plays vital role in completely automatic hospital sterilizer

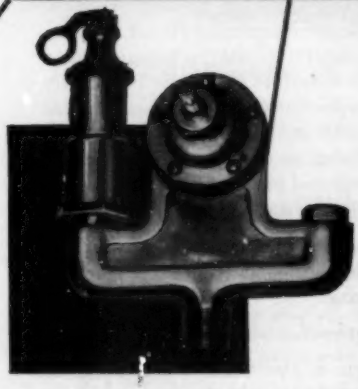
Efficient sealing and controlling of steam at either high or low pressure is a tough job for any ordinary material — *but it's easy for Graphitar.* That's why Graphitar was selected as a seal and control rotor in the operating valve of the American *CyclomatiControl* Automatic Hospital Sterilizer made by the American Sterilizer Company of Erie, Pa. This completely automatic sterilizer is designed to *"relieve the human element in sterilizer operation"*, and its makers realized the value of Graphitar as one of its most important parts. Graphitar will not seize, score, burn or distort *regardless of heat or pressure* — it will withstand temperatures up to 600°F and pressures of 75 lbs/sq. in. Use of Graphitar parts at such vital points eliminates replacement costs and maintenance shut-downs.

GRAPHITAR

(CARBON-GRAPHITE)

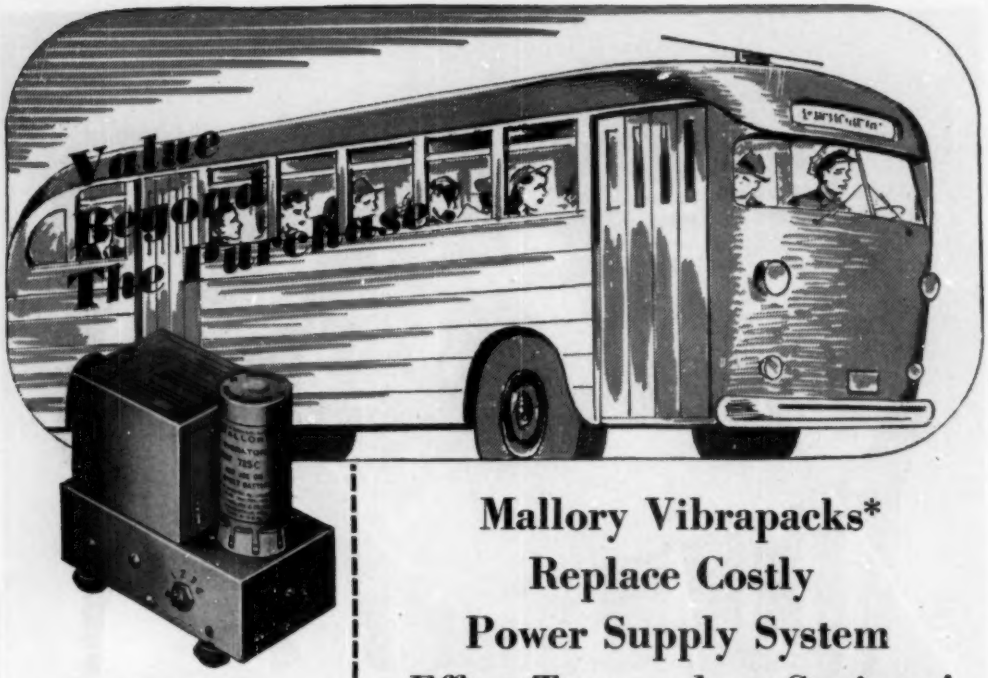
THE UNITED STATES GRAPHITE COMPANY





Graphitar is a carbon-graphite product of many unique characteristics valuable to industry. It is practically unaffected by temperature extremes and so chemically inert that even boiling concentrations of corrosive acids will not affect it. It is *mechanically strong, yet extremely light in weight* — lighter than magnesium. Graphitar is available in several grades, either dry or self lubricating, to meet particular specifications. It can be molded into seals, bearings, rings, pistons and other parts — it can be ground to tolerances as close as .0005" in small sizes. Our engineers may be able to suggest Graphitar applications that *will improve the efficiency* of your products. Send us prints for recommendations without obligation. ***Ask for your copy of the 64 page Graphitar Catalog.***

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN



MALLORY VIBRATORS

Mallory Vibrators and Vibrapack power supplies are based on exclusive design and manufacturing methods that assure long, trouble-free service. Send the details of your application. Get Mallory's recommendation on the Vibrator or Vibrapack power supply best suited to your needs.

Mallory Vibrapacks* Replace Costly Power Supply System *Effect Tremendous Savings!*

In one typical case, a simple and inexpensive circuit modification, developed by Mallory, made it possible for a manufacturer of mobile radio receivers to substitute Vibrapacks for a costly and less efficient power supply system. The conversion saved this Mallory customer $40,000 in the first year! In addition, thousands of dollars are being saved in maintenance costs. Servicing the old system required hours of labor . . . the new one requires only occasional replacement of the vibrator.

When you buy Mallory vibrator equipment you benefit by a winning combination of dependability, economical performance and creative engineering.

That's value beyond the purchase!

And whether your problem is electronic or metallurgical, what Mallory has done for others can be done for you!

Vibrators and Vibrapack Power Supplies

P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

SERVING INDUSTRY WITH

Capacitors	Contacts
Controls	Resistors
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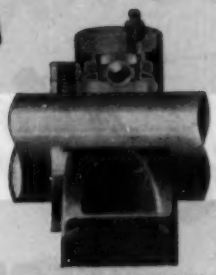
Special Switches	Power Supplies

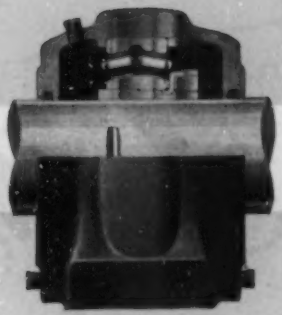
Resistance Welding Materials

*Reg. U.S. Pat. Off.

Lock a LINK-BELT Ball or Roller Bearing to your shaft



BALL BEARING—SERIES 200



ROLLER BEARING—SERIES 6800

without distortion

because . . . the set screws are not threaded into the inner ring of the bearing. The spring-locking collar, or the tapered sleeve, clamps the bearing to the shaft.

with firm grip

because . . . of the "hoop tension" of the spring-locking collar, or the tight grip of the tapered sleeve.

without mislocation

because . . . the spring-locking collar is factory assembled and permanently located in correct position on the bearing.

regardless of rotation

because . . . of symmetrical locking. Two simple operations securely lock a LINK-BELT bearing. Simply slip on shaft; then tighten two set screws, or pull up the locknut.

with wide distribution of bearing load

because . . . the wide inner ring of the bearing, or the tapered sleeve, provides a large area of shaft contact.

May we send you the new Link-Belt Ball and Roller Bearing Catalog No. 2550, containing complete data useful in design and replacement? Link-Belt engineers are quickly available to discuss your bearing problems. Contact the nearest office.

LINK-BELT COMPANY Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Ho- ton 1, Minneapolis 3, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities. 11,700

A complete line of bearings is available from stock, throughout the country, in pillow blocks, cartridge, flanged cartridge, flanged, hanger and takeup blocks —also unmounted bearings.

LINK-BELT

BALL & ROLLER

BEARINGS

Consider the

BEFORE YOU CHOOSE POWER TRANSMISSION, TIMING AND CONVEYING EQUIPMENT

When you are facing today's most pressing problem, designing for lower costs, it's important to consider carefully the conditions under which your power transmission, timing or conveying equipment must operate.

Slow speeds, high speeds, light loads, heavy loads, long centers, short centers, heat, dust, corrosion, abrasion, these are the factors that should determine your choice. From the standpoint of first cost and operating cost to your customers, the medium selected must meet the conditions.

There is no one best or stock answer. That is why we at Chain Belt Company feel that we can be of practical assistance to you in cutting costs . . . improving product performance. Because we manufacture *a complete line of chains,* we can help you select the chain that is exactly right for your machines. Our Field Sales Engineers are not limited to a single type of chain. They can recommend, without prejudice, the chain that will stand up. Conversely, they can recommend a lighter chain, if your designs are overchained, with important cost advantages to you. Our Field Sales Engineers will be happy to assist you in reviewing your chain selections. Call or write the Chain Belt Field Sales Office near you or, if you prefer, mail the coupon below.

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CHAIN BELT COMPANY

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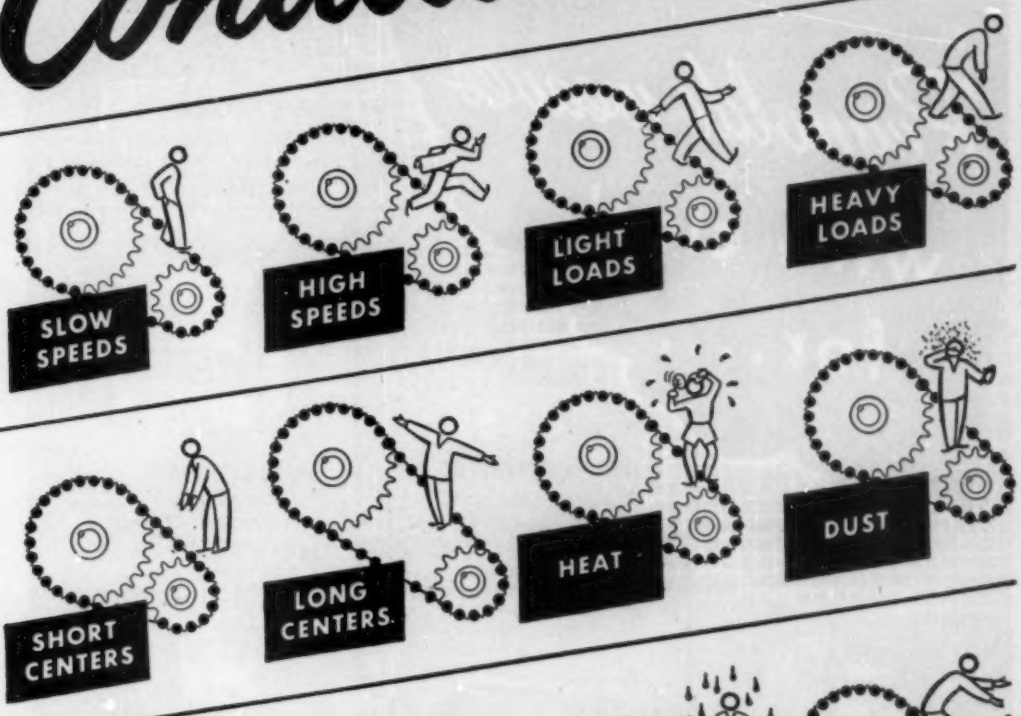

THE COMPLETE CHAIN BELT LINE

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Baldwin-Rex Double Pitch Roller Chains
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Rex Double-Flex Chains
Rex Sugar Mill Chains
Rex Chabaico Steel Chains
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and a complete line of chain attachments.

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Chain Belt Company
1713 West Bruce Street, Milwaukee 4, Wisconsin

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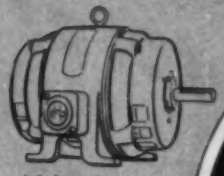
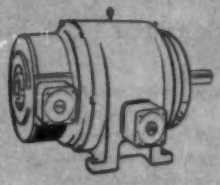
ONE SOURCE

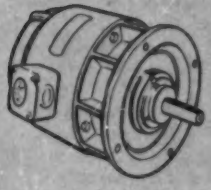
For the Broadest Range of Motor Requirements



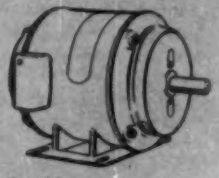
Special duty motors



Wound rotor motors



Flange mounted motors



Fractional horsepower motors

Single phase (integral horsepower) motors

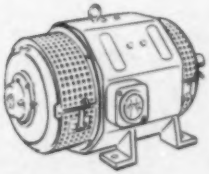
Vertical motors

For Motors..

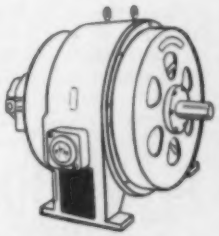
Look for this name plate!

Whether you are interested in a single motor, or a thousand—one type and size, or a variety of types and sizes—you'll find that any and all you need are designed and built by Fairbanks-Morse. How important this is to you depends on how much you want to deal with a single, up-to-date source of motors—a company of long-time experts in designing and building motors for all uses—a group of electrical specialists who will give you sound, unbiased help in motor application.

If you want these advantages... then, for motors, look to Fairbanks-Morse.



Direct current motors



Synchronous motors

Single phase (fractional horsepower) motors

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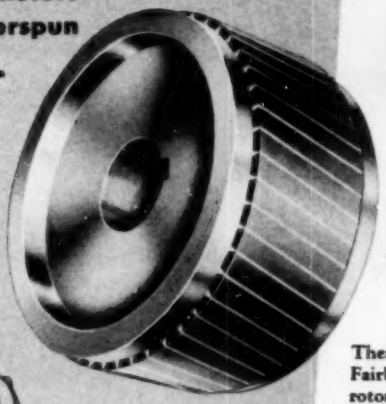
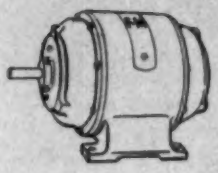
the Name is . . .

All popular sizes of Fairbanks-Morse Polyphase Squirrel Cage motors have the Copperspun ROTOR—

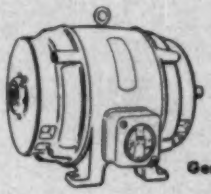


For example . . .



Explosion-proof motors

Totally enclosed non-ventilated motors



General purpose protected frame squirrel cage motors

before you buy motors . . .

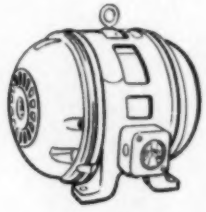
Compare Rotors!

Only Fairbanks-Morse offers the indestructible, *Copperspun* rotor

There's longer life built into every popular Fairbanks-Morse motor. It is the Copperspun rotor, the exclusive centrifugal cast rotor that is as indestructible as such a moving part can be—and as it should be. The Copperspun rotor with its sturdy, well proportioned shaft is dynamically balanced—to run quietly and smoothly through more years of service than you can expect from ordinary motors. The Copperspun rotor is an added, exclusive advantage you get when you specify Fairbanks-Morse for motors.

Why not talk over Fairbanks-Morse motor design and its benefits with a Fairbanks-Morse specialist? Write or call the nearest Fairbanks-Morse branch office listed on these pages.

Totally enclosed fan cooled motors



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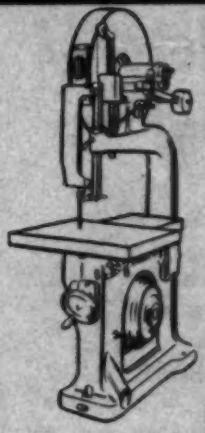


BAND SAW. An Axial Air-Gap motor cuts down on width and smooths operation of this new woodworking machine.

VENTILATOR FAN. Note how an Axial Air-Gap motor reduces height and simplifies fabrication of this ventilating fan.

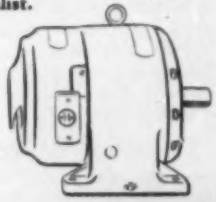
CAR PULLER. The Axial Air-Gap motor saves space and weight—making an attractive, compact and sturdy unit.

solve problems like these with Axial Air-Gap Motors

Lighter Weight—Shorter Length Ideal for Scores of Uses

Since the advent of the Fairbanks-Morse Axial Air-Gap motor, literally hundreds of users have turned to it because it offers the benefits of approximately 30% less weight and 40% shorter over-all length than conventional motors. Actually wherever size, weight and appearance of the driven machine are important, the Axial Air-Gap motor has proved to be a useful, unique and more than satisfactory solution. Designed and built with all of the Fairbanks-Morse traditional regard for strength, balance and minimum of maintenance, Axial Air-Gap motors incorporate, too, the well known Copperspun rotor design. Because of the large diameter of the rotor, the flywheel effect is approximately three times that of corresponding conventional ratings—making it ideal for applications not involving repeated plugging and reversing duties.

There are many other things you should know about Axial Air-Gap motors if you are designing motor-driven equipment—or in any other way involved with motor selection. Consult your Fairbanks-Morse sales specialist.



MOTORGEAR. The Axial Air-Gap motor combined with a helical gear reducer makes industry's smallest, lightest, most compact, slow speed unit. (Up to 10 hp.)

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MORE ON NEXT PAGE

the Name is... **FAIRBANKS-MORSE**

If you Buy, Specify or use Motors, You Need this Information!

"Pocket Panorama" of the complete line of Fairbanks-Morse Motors—Generators

Here is a handy reference which shows the complete line of Fairbanks-Morse motor and generating equipment along with basic information on each unit. Over 40 sizes and types illustrated—good usable data for anyone concerned with motor selection and application.

Famous "Catechism of Electrical Machinery" an invaluable reference

Here is a fund of basic information on the design, performance and proper use of the common types of direct current and alternating current motors, generators and control equipment. Primarily intended for those who are not widely familiar with electrical phenomena or terminology, it also has been widely accepted by engineers, maintenance men, designers and others as an aid in instruction of new men for factory, engineering or sales departments. Used by the thousands in some of the country's leading technical institutions it has no equal in simplifying and explaining the intricacies of electrical machinery.

Your Request written on your letterhead, addressed to your nearest Fairbanks-Morse Branch Office (listed on these pages) will be promptly answered.

FAIRBANKS-MORSE,

a name worth remembering

DIESEL LOCOMOTIVES AND ENGINES • ELECTRICAL MACHINERY • PUMPS • SCALES
HOME WATER SERVICE AND HEATING EQUIPMENT • RAIL CAR • FARM MACHINERY

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How to give Your Product a New "Magnetic Personality"...

No. 1205 Veeder-Root Magnetic Counter (AC only) is compact, readily adaptable for building into many types of products as standard equipment. Counts to million, then resets. Specification sheet on request.

...give it a Sales Build-up with Built-in Magnetic Counters

Lucky are the products that can avail themselves of the added usefulness—*the new sales-magnetism* — imparted by this modern Veeder-Root Magnetic Counter. And such products vary as widely as currency-counting machines, conveyors, electronic equipment, and other electrically operated devices equipped with contact switches.

But if your product has a "hidden talent" for counting either electrically *or* mechanically, Veeder-Root engineers know how to discover and develop that talent . . . and how to enable your product *to talk to your customers in any terms they want.* In terms of any units of performance, production, volume, length, or what have you. Yes, Veeder-Root Counters not only help sell the products they're built into . . . they can even prove the product's service guarantee! Now, when would you like a "talent scout" to look at your product . . . *to see whether you can count yourself lucky, too?* Just write.

Write for 8-page "Count Book" which shows all types of V-R electrical, mechanical, and manual counters . . . standard and special.

Veeder-Root COUNTERS

VEEDER-ROOT INC., HARTFORD 2, CONN.
In Canada: Veeder-Root of Canada, Ltd., 955 St. James Street, Montreal 3.
In Great Britain: Veeder-Root Ltd., Kilspindie Road, Dundee, Scotland.

15/16" cut removes 59.4 cu. in. of metal per minute with no sign of chatter!

HERE'S a terrific test staged by the Sidney Machine Tool Company to demonstrate the capacity of their 32" lathes. Using a carbide tool without lubrication, this heavy cut was continued for 20 minutes without interruption. Yet no sign of chatter appeared on the work!

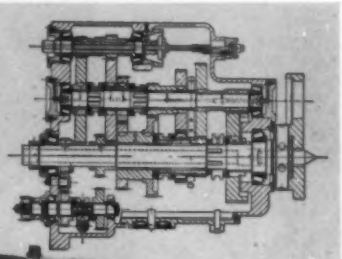
Mounted on Timken® bearings, Sidney lathe spindles stay rigid and free from vibration under the heaviest cuts. Due to the line contact between the rolls and races, Timken bearings give the spindle maximum support, minimum deflection. Tapered construction enables Timken bearings to carry both radial and thrust loads in any combination and permits accurate preloading.

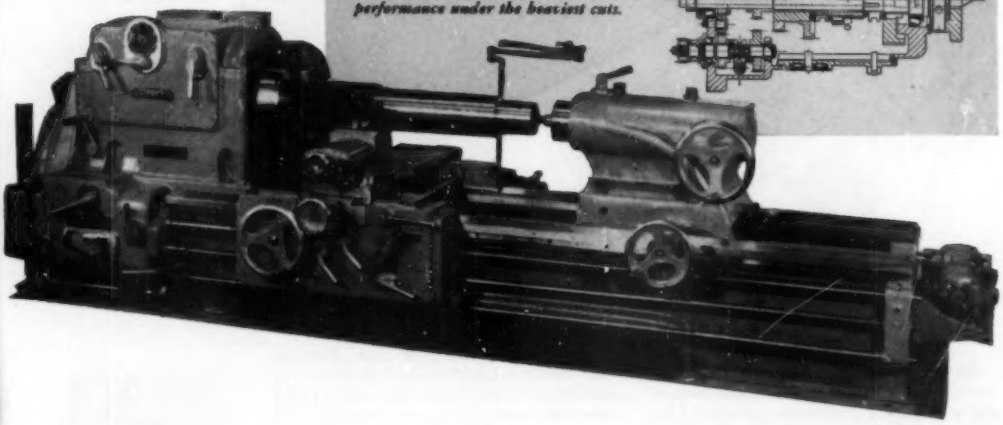
Timken bearings are made of the best steel ever developed for tapered roller bearings—Timken fine alloy steel. True rolling motion and the finishing of the rolls and races to incredible smoothness practically eliminate friction. Fine bearing performance and accurate operation are assured throughout the life of the machine.

Backed by 50 years of bearing research and development, Timken tapered roller bearings are first choice throughout all industry. Make sure you have Timken bearings in every machine you make or buy. Look for the trade-mark "Timken" on the bearings. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best

Here's how SIDNEY MACHINE TOOL CO. *uses Timken bearings throughout the headstock of their 32" lathes—for smooth, accurate, chatter-free performance under the heaviest cuts.*





NEW TIMKEN BEARING CUTS RUN-OUT IN HALF!

Until now, the Timken "Zero" bearing has been the last word in bearing accuracy. Now Timken offers industry the "Double-Zero" bearing—*twice as accurate* as the "Zero"! Maximum run-out of the new "Double-Zero" bearing is only 75 millionths of an inch—*half* the 150 millionths run-out of the "Zero" bearing.

What an opportunity for manufacturers of machines where extreme accuracy is essential! Available in standard single row types, up to 10" O.D. Write for further information.

TIMKEN

TRADE MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ◎ AND THRUST →◎← LOADS OR ANY COMBINATION ✳

This resilient tape makes it easy to

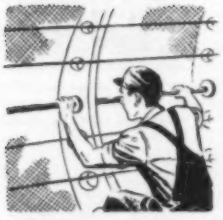
- cushion adjacent parts
- eliminate squeaks
- simplify assembly
- make units non-skid

One of the simplest ways to handle the jobs mentioned above is to apply Armstrong's DK-153 Tape. Quick and easy to use, it protects adjacent parts from rubbing, quiets squeaky joints, and makes slippery surfaces non-skid.

Armstrong's DK-153 Tape is a compressible, high-friction material, made of cork-and-sponged-rubber and backed with a pressure-sensitive adhesive. It is easy to apply. You merely strip the fabric backing from a piece of Armstrong's Tape and press into place on any clean, dry surface. For extra convenience in assembly, this tape can be supplied in the form of die-cut parts.

Whether you make diesel locomotives or pottery lamps, airplanes or dial telephones, there is probably a place in your product where Armstrong's DK-153 Tape can do a similar job for you. Or perhaps it can do an existing job, better and more easily.

In either case, we'd like a chance to demonstrate the capabilities of Armstrong's DK-153 Tape. For further information, samples, and prices write Armstrong Cork Company, Gaskets and Packings Department 7104 Arch Street, Lancaster, Penna. Available for export.



CUSHION ADJACENT PARTS

Aircraft wiring, cushioned with Armstrong's DK-153 Tape at points where it passes through bulkheads and structural members, is protected from excessive chafing. Because this tape is compressible, it also prevents insulation crushing when positioning flanges are tightened.

ELIMINATE SQUEAKS

Strips of Armstrong's DK-153, applied to structural members in railway coaches and diesel locomotives, absorb relative motion and prevent sliding between panels and frame. Thus, it eliminates squeaks and prevents destructive abrasion between panels and framework.

SIMPLIFY ASSEMBLY

The pressure-sensitive adhesive backing on Armstrong's DK-153 Tape simplifies assembly for a pottery lamp manufacturer. Die-cut to the shape of the lamp bottom, pads of Armstrong's Tape are ready to use without the time-consuming hand gluing operation, previously required.

MAKE UNITS NON-SKID

To prevent dial telephones from slipping on polished surfaces, many local telephone companies now equip their phones with non-skid pads cut from Armstrong's DK-153 Tape. These pads may be applied at the factory or by the telephone serviceman at the point of use.

ARMSTRONG'S DK-153 TAPE

One of Armstrong's Cork-and-Rubber Products

Designer's

NOW! PACKAGED ADJUSTABLE-SPEED CUSTOM-ENGINEERED FOR YOU!

Yes, these and many other features of Thy-mo-trol®—features that make it the most accurate, most versatile, and fastest-acting of all General Electric packaged adjustable-speed drives—are now standardized with new "building block" flexibility. That means you can order this wonder-working, all-electronic system with just the combination of standard and optional features you need. Already service-proved on thousands of machines, Thy-mo-trol now more than ever meets your most demanding requirements. In addition, and at lower cost, its new "building block" design allows you in many instances to use it economically for your less exacting applications. Made in standard ratings from 1/40 to 30 hp, it's fully described in Bulletin GEA-5337.

STANDARDIZED THY-MO-TROL DRIVES

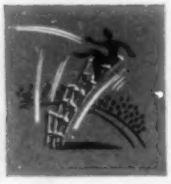
—with features like these teamed to meet your most exacting needs!

Any speed range from 5:1 up to 100:1. Select the range you need, no more, no less.

Stepless speed adjustment to give you an infinite choice of speeds within the rated range.

Easy automatic operation, using geared or cam-driven potentiometers, selsyns, or reactors.

Preset speed with push-button control of any operating, jogging, or creeping speeds.



Torque limit protection to minimize the possibility of damage should the machine jam or be overloaded.

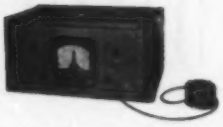
Complete speed control from start to stop—including acceleration, deceleration, and reversing.

Precise speed regulation to the accuracy required—even 0.5%—despite voltage or motor temperature changes.

GENERAL ELECTRIC

648-81

Digest GE PRODUCT HIGHLIGHTS

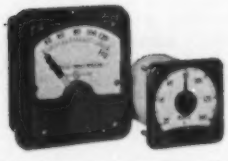


TO TEST METAL PARTS —*QUICKLY!*

Here's a fast, economical way to reduce scrap loss due to mixed material or incorrect processing of ferrous or nonferrous parts. Compare their composition, heat treatment, hardness, or plating thickness against a standard by means of the General Electric metals comparator. Equipment comprises an electronic unit mounted in a steel cabinet, plus either a test coil (shown) or a test head, depending on the shapes of parts to be tested. Operates from a single-phase, 60-cycle, 110-volt supply. See Bulletin GEC-566.

TO ADJUST LOW-RANGE SPEEDS —*STEPLESSLY!*

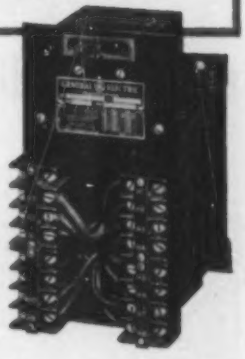
Newest line added to General Electric's Tri-Clad motor family is the a-c adjustable-speed gear-motor for stepless speed adjustment in the low ranges. In standard ratings from 3-15 hp, 35/12 to 602/201 rpm, this compact unit combines a standard type ACA motor with an AGMA Class II open horizontal gear unit. Result: mounting is easier, space is saved, installation and maintenance costs are cut. What's more, efficiency is high because of low motor and gear losses. See Bulletin GEA-4883.



TO CHECK TEMPERATURES —*ACCURATELY!*

Most temperatures commonly met in industry can be accurately, remotely measured with General Electric temperature indicators. In two types, they provide a wide temperature span and high speed of response. Resistance thermometers cover the range up to 300 F, have a minimum span of 150 F each and an accuracy up to ±1 per cent. Thermocouple thermometers, with round or square cases, measure from −50 to 3000 F with a minimum span of 250 F each, are accurate to ±2.5 per cent, and, with accessories, can be used portably or panel mounted. See Bulletin GEC-565.

Versatile Transformer FOR A Variety of Voltages



Here's a point to remember: Standards recently recommended by the Joint Industry Conference are more than met in General Electric's complete line of machine-tool control transformers.

The all-purpose (multi-tap primary) group is made in ratings from 0.150 to 3.0 kva for both 50- and 60-cycle circuits. Equipped with eight primary taps—208, 220, 380, 400, 416, 440, 500, and 550 volts—110/92-volt secondary, these versatile units fit practically every input-voltage condition, reduce inventory and storage costs. Compact design saves panel space, simplifies wiring. Built-in protection against damage from short circuits and sustained overload is also included. For more information, write for Bulletin GEA-4887.

General Electric Company, Section C668-81
Apparatus Department, Schenectady 5, N. Y.
Please send me the following bulletins:

√ for references purposes
X in connection with immediate projects

- ☐ GEA-4883 — Adjustable-speed gear-motors
- ☐ GEA-4887 — Machine-tool transformers
- ☐ GEA-5337 — Thy-mo-trol drives
- ☐ GEC-565 — Temperature indicators
- ☐ GEC-566 — Metals comparator

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

Name_____

Company_____

Street_____

City_____ State_____

For maximum van trailer lightness, manufacturer designs floor of Dow

MAGNESIUM

the world's lightest structural metal!

Magnesium Extrusions— light, strong, versatile

To withstand the severe shock and bending loads imposed by fork lift trucks, the manufacturer designed this lightweight multi-ribbed section. Here again the flexibility of the magnesium extrusion process made it possible to tailor this lightest of structural metals to job requirements—cutting fabrication costs to a minimum.

More than 650 lb. of costly dead weight removed from a 32-foot van trailer! That's what happened when a leading manufacturer designed a floor made up of *full length* extruded magnesium "boards".

Not only does the extruded magnesium floor weigh significantly less than the heavy floor it replaced, it is also 83% stronger and requires much less maintenance. In addition, the new floor is free from troublesome splinters and does not pick up objectionable odors from the cargo.

Magnesium is a wise choice for lightweight strength and durability. A full one-third lighter than any other structural metal, magnesium's high strength-weight ratio permits strong, rigid designs of surprising lightness. Magnesium is versatile, too. Available in all common forms, it is easily fabricated by simple, established shop procedures. For technical information about magnesium, call your nearest Dow sales office, or write Dept. MG-44 in Midland.

Magnesium Division

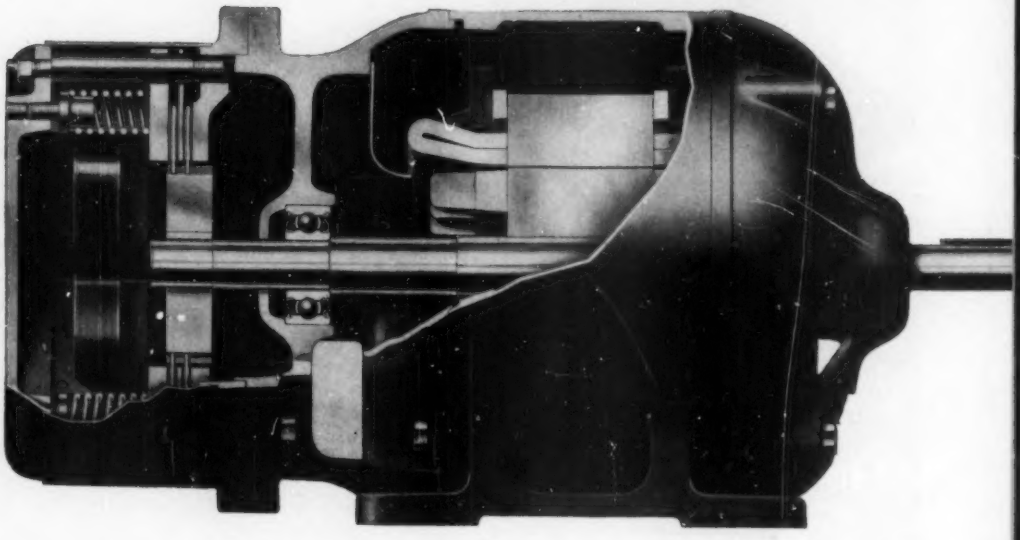
THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington • Atlanta • Cleveland • Detroit
Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada

Lighter Products Sell—make your products Magnesium Light!

They make friends.....
FAST
Wallace Barnes Springs
Bristol Connecticut

NEW! MONEY-SAVING CROCKER-WHEELER BRAKE



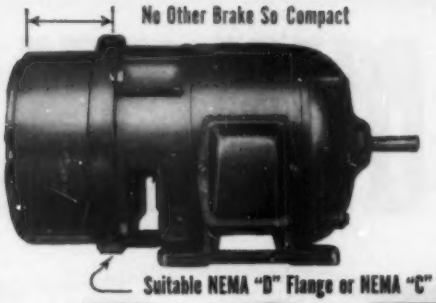
Now—from the pioneer in motor improvements comes a Brake Motor engineered a step ahead of any in its field... to bring you maintenance savings never before possible!

Here's the Brake Motor by which all others will be measured! From wear-resistant brake linings of bonded metal to the compact dimension of its totally-enclosed brake, this new motor is another Crocker-Wheeler *dollar-saver.*

Check these exclusive features—every one engineered to cut operating, maintenance and replacement costs.

Bonded metal brake linings practically eliminate the need for adjustments, outlast others 3 to 1. Brake adjustments, if necessary, may be made from the outside. Rotating disc and lining can be replaced for less than cost of equivalent replacement in old-style brakes. Automatic re-set hand release supplied as an extra when specified.

With its short overall mounting dimension, the brake can be used where space is limited. Brake unit is available for separate mounting—the only brake that can be attached to a standard double shaft D flange motor for frames 203-326 or C face motor for frames 364-405. Get all the facts on the many money-saving features of the new C-W Brakemotor. Send today for new Bulletin. Simply mail the coupon on the opposite page.



MOTOR

No other Brake Motor has all these features to cut your operating and maintenance costs

- *Bonded metal brake linings — for greater wear resistance. All-metal construction practically eliminates adjustments and replacements.
- All brakes totally enclosed for added protection.
- *No torque or lining wear adjustment necessary on #11 or #11A brakes.
- Large diameter brake spline with large number of teeth decreases load per tooth . . . increases life of spline and rotating discs.
- Brake lining wear adjustments (*if necessary*) can be made from *outside*. No need to remove cover or posts.
- *Short overall mounting dimension. C-W Brake is compact—an advantage in fitting motor into tight places.
- Simple wrap-around band cover. No room needed at end of brake for cover removal, as with covers that slide off and so require clearance.
- Torque elements close to mounting flange eliminate difficulties often encountered with overhung brakes. No possibility of excessive bearing stresses or weakened shaft support under loads, as can happen when braking force is at the end of shaft, away from bearing.
- Brake leads are brought into the motor conduit box so that they can be connected in motor circuit or energized separately. Saves wiring trouble in original installation.
- Magnets and springs symmetrically spaced for equalized pressure and low brake lining wear.
- *Brake unit can be mounted on suitable NEMA standard D flange (frames 203-326) or C face (frames 364-405) motors (with double shaft extensions). No special mounting brackets or adapters required.

*Exclusive on the Crocker-Wheeler Brake Motor.

ELLIOTT COMPANY

CROCKER-WHEELER DIVISION,

BRANCH OFFICES: Atlanta, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Houston, Kansas City, Los Angeles, Milwaukee, Minneapolis, New Orleans, New York, Newark, Philadelphia, Pittsburgh, St. Louis, Salt Lake City, San Francisco, Seattle, Tulsa, Washington, Wilmington. Representatives in principal cities.

AMPERE, N.J.

Sealedpower Motors

Protected-Type Motors

Wound-Rotor Motors

Direct-Current Motors

Elliott motors and generators larger than the Crocker-Wheeler line are built by the Ridgway Division at Ridgway, Pa.

Elliott Company, Advertising Dept., Jeannette, Pa.

Please send new Bulletin SL-610-1, describing Crocker-Wheeler Brake Motors.

PD-450

Name_____

Title or Function_____

Company_____

Address_____

ANNOUNCING

AN ELECTRIC *Power-Packer*

...and you can DEPEND on it!

Blackhawk recommends this highly efficient, four-piston, positive-displacement pump unit with full confidence. It is the *only* adequate answer for the many problems presented by 6-volt D.C. hydraulic operation. Over five years of closely-observed service, in varied applications, reveal that this design has hurdled all the problems of battery-operated pumps. Its maximum efficiency eliminates costly down-time and battery failure.

Six Big Advantages of the Electric Power-Packer

1. **Speed** — it lifts the load three times faster than hand operation.
2. **Remarkable Efficiency** means low battery drain.
3. **Positive Displacement** — no slippage under varying temperature and load conditions.
4. **Control** is simple, precise! It lifts and lowers at any desired speed — and holds the load, too.
5. **Quiet, Smooth Operation** — no peak loads on the battery.
6. **Simple Installation** — it is a complete package — pump, reservoir, valve and electric head. Or it can be secured without a reservoir for converting hand-operated Power-Packers. It is easily adapted to remote operation.

The Electric Power-Packer is a complete control unit. It is available in two models — covering an extensive, practical operating range.

BLACKHAWK HYDRAULIC EQUIPPED

AN EMBLEM REPRESENTING DEPENDABILITY THROUGHOUT INDUSTRY

PIONEER SPECIALISTS IN HIGH-PRESSURE HYDRAULICS FOR 25 YEARS

THREE MORE HYDRAULIC *Power-Packer* PACKAGES!

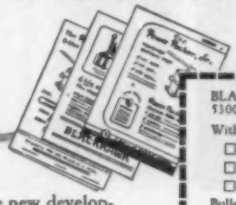
THE HAND-OPERATED *Power-Packer, Jr.*

Its LOW-COST permits hydraulics on a broadened range of equipment

This refined, compact pump series has proved extremely practical for equipment which must be priced at an especially low level. It has the added merit of serving in close quarters and where extra weight is undesirable. It also is an adequate emergency or stand-by unit for hydraulic power-driven systems. Power-Packer, Jr., pumps are available for three maximum pressure levels . . . 6000, 5000 and 2500 p.s.i.

A POWER-DRIVEN *Power-Packer*

A variety of power sources can be used to operate this Power-Packer series. This unit combines a pump, valve and reservoir in *one package* . . . and that means reduction of installation costs and problems. The pump, with its positive displacement and high-pressure range, has the same dependable characteristics of Blackhawk's popular P-104 pump. The valve exerts precision throttling in both raising and lowering.



You are invited to request bulletins on each of these new developments and other Blackhawk Hydraulic products for original equipment. Engineering counsel is willingly furnished — in confidence.

BLACKHAWK MFG. CO.
5300 W. Rogers, Milwaukee 1, Wis.

Without obligation, send following:

- ☐ Bulletin on Electric Power-Packer
- ☐ Bulletin on Power-Packer, Jr.
- ☐ Bulletin on Power-Driven Power-Packer

Bulletins on: ☐ Rams ☐ Valves ☐ Complete Pump Line

Name.....

Title.....

Firm.....

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City.....State.....

BLACKHAWK

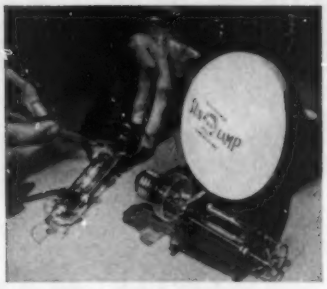
If you use WIRE...

chances are you could do a better job...a safer job ...a longer-lasting job...a cheaper job, if you changed to wire made of Monel® ...or Nickel...or Inconel®

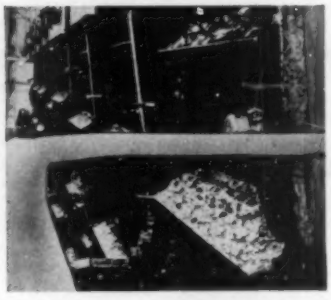
EMBLEM OF SERVICE INCO TRADE MARK

SEE FOR YOURSELF. Send for new folder, "If Wire Has You Snarled." It gives information on the mechanical and corrosion-resisting properties of Monel, Nickel and Inconel wire. Also includes a sample length of Monel wire.

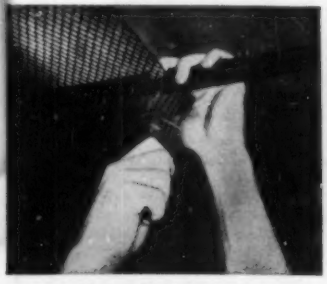
THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.



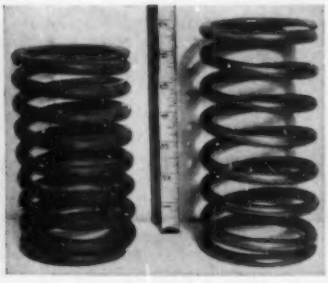
1. *750°F.* is the operating temperature within the Westinghouse Sun Lamp. But Westinghouse has no wire worries. Flexible, 38-strand Nickel wire is used for inside conductors to provide electrical conductivity while resisting heat. The sturdy structural frame supporting the whole assembly is made of "D"® Nickel wire.



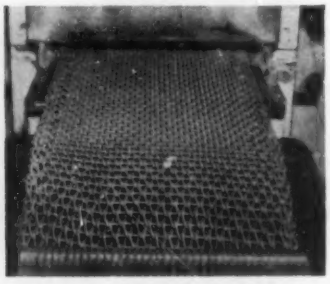
2. ***Corrosion*** quickly would have ruined ordinary metal wire on these salt-water trash screens. But the operator (a leading chemical company) planned for long life—and got it—with Monel. Installed in 1940, not a single Monel screen has yet to be replaced because of corrosion failure.



3. ***Strength*** is only one of the many properties needed in architectural tie-wire. Also needed, is resistance to attack by building dampness, lime, cement, plaster. The metal must be workable, too, so that it can be twisted tight without breaking. *Monel* tie-wire ends the wire worries of many architects. "Double-Looping" is not needed.



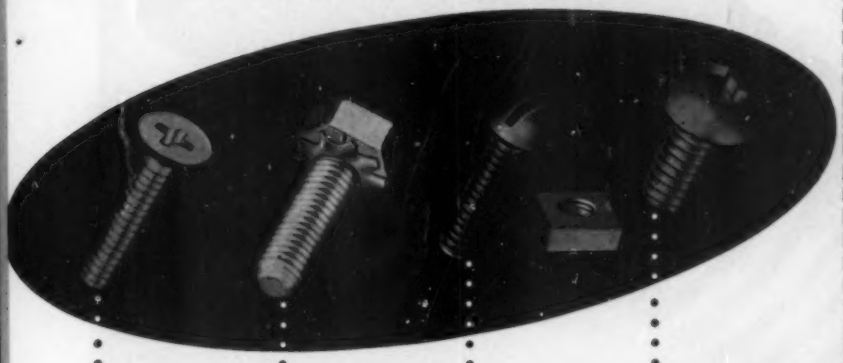
4. ***Springs*** of Inconel perform well at elevated temperatures. In the above picture, both springs were originally 7" long. After compression testing at 750°F., the spring at left lost 1" of its original height. The Inconel spring (at right) lost nothing. Remember this when you're choosing springs for "hot spots."



5. ***Resistance to oxidation and heat*** were twin "musts" for the wire used in this conveyor belt to carry parts through a brazing furnace at 1300-2040°F. Made of woven Inconel wire, this belt was in constant use for more than two and a half years; was still serviceable and strong when the furnace was dismantled.

TIME SAVERS WITH SALES APPEAL

FOR LIGHT-METAL FASTENING



PHILLIPS HEAD SCREWS with the famous patented recess that centers the driver automatically. Powerdrivers may be used at high speeds without danger of slipping. Withstands high torque pressures because strain on screw is exerted deep in the head.

SEMS are pre-assembled lock-washer screws that speed assembly operations by eliminating an extra operation and time-wasting fumbling. Washers rotate but cannot come off. Available with many different types of washers and heads.

SLOTTED HEAD MACHINE SCREWS and nuts. The "old reliable", in its finest form! Lamson machine screw heads are uniformly concentric, slotted deeply and accurately. A wide range of sizes available.

CLUTCH HEAD SCREWS require little end-pressure on the driver. No "back-out" tendency! Driver bit sticks in screw recess when bit is turned to left—releases when screw is tightened down.

Fasteners in STEEL, BRASS, BRONZE *and* ALUMINUM

• Inefficiency on assembly lines can often be traced to fastener troubles. Therefore it's important that fasteners be selected to do the job with a minimum of waste motion, fumbling and product damage.

Lamson & Sessions makes a wide selection of fasteners especially engineered to perform hundreds of assembly jobs faster and therefore, at less cost.

If you suspect that fastener inefficiency is slowing up your assembly line, tell us your problem and chances are we can suggest a remedy.

The LAMSON & SESSIONS *Co.*

General Offices: 1971 West 85th Street, Cleveland 2, Ohio

Plants at Cleveland and Kent, Ohio • Birmingham • Chicago

MAKERS OF FINE FASTENERS SINCE 1866

TS • NUTS • SCREWS • COTTERS • STUDS • RIVETS • SPECIALS • SCREW MACHINE PRODUCTS

—CUT ALONG THIS LINE—

MONEY-SAVER FASTENERS *Pay Dividends*

LAMSON LOCK NUTS: Economical, vibration-proof. Can be re-used repeatedly.

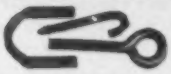
"1035" SET SCREWS: Cup point type, hardened, heat-treated.

COTTER PINS: Steel, Brass, Aluminum and Stainless Steel.

SPECIAL NUTS: Cone, Barrel, Oblong, Plier, Tri-Slot, Half-round, etc.

PHILLIPS AND CLUTCH HEAD: Machine Screws and Tapping Screws.

MILLED STUDS: Concentric, accurate, in a full range of sizes.



"BENT" BOLTS: Including U Bolts, Eye Bolts, Hook Bolts, etc.

WEATHER-TIGHT BOLTS: Eliminate counter-boring in wood assemblies.

PIPE PLUGS: Forged Steel, heat-treated.

FOR MORE INFORMATION ON LAMSON *Money-Saver* FASTENERS . . . . . CHECK COUPON and CLIP THIS STRIP

The Lamson & Sessions Company
1971 W. 85th St., Cleveland 2, Ohio

The UNBRAKO Socket Head Cap Screw

...is specified by designers and production men everywhere because of its *time-saving* knurled head and its uniformly high quality.

See us at Space 128, A. S. T. E. Exposition,
April 10-14, Convention Hall, Philadelphia

Knurled Head Socket Cap Screws
Flat Head Socket Cap Screws
Self-Locking Socket Set Screws

SOCKET UNBRAKO SCREWS

Knurled Head Stripper Bolts
Precision-Ground Dowel Pins
Fully-Formed Pressure Plugs

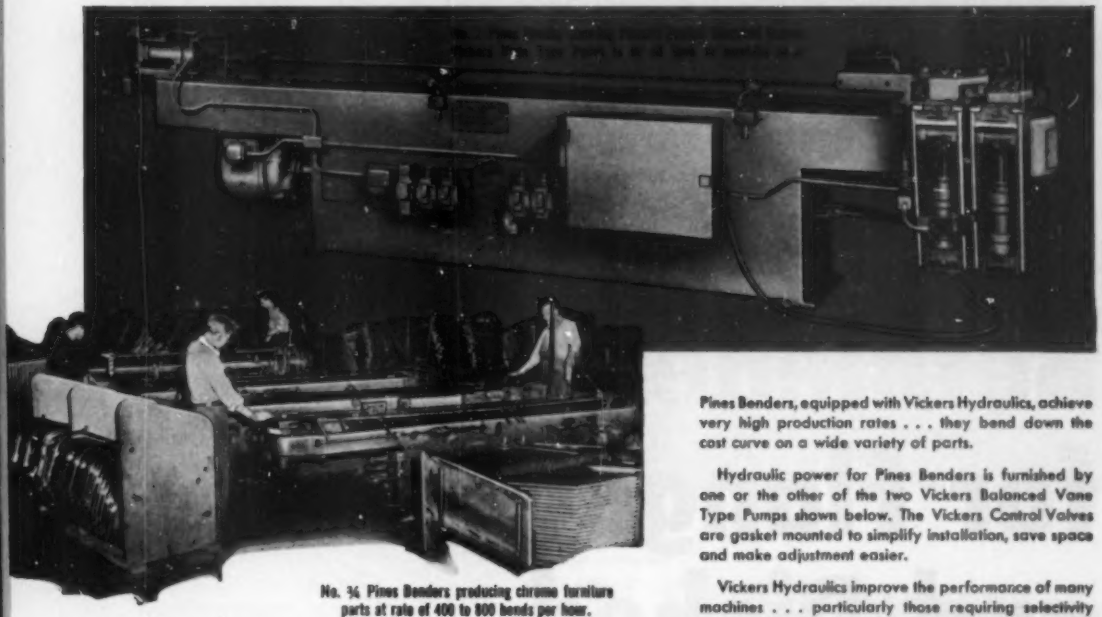
SPS STANDARD PRESSED STEEL CO.

JENKINTOWN 28, PENNSYLVANIA

Bending the Cost Curve DOWN

PINES BENDERS

Another Cost-Cutting Application of VICKERS HYDRAULICS



No. ¾ Pines Benders producing chrome furniture parts at rate of 400 to 800 bends per hour.

Pines Benders, equipped with Vickers Hydraulics, achieve very high production rates . . . they bend down the cost curve on a wide variety of parts.

Hydraulic power for Pines Benders is furnished by one or the other of the two Vickers Balanced Vane Type Pumps shown below. The Vickers Control Valves are gasket mounted to simplify installation, save space and make adjustment easier.

Vickers Hydraulics improve the performance of many machines . . . particularly those requiring selectivity of control and adjustment to suit type of work. Any sequence of motions can be provided . . . made automatic if desired. Vickers Hydraulic Equipment is easily protected against overload; incorrect or unsafe operation can be prevented by interlocks. Contact the Vickers Application Engineering Office near you for suggestions on how Vickers Hydraulics can improve your machinery. Write for Catalog 4900.

VICKERS Incorporated

DIVISION OF THE SPERRY CORP.

1454 OAKMAN BLVD. • DETROIT 32, MICH.

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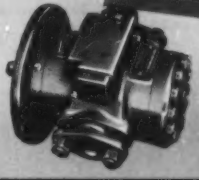
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

4183

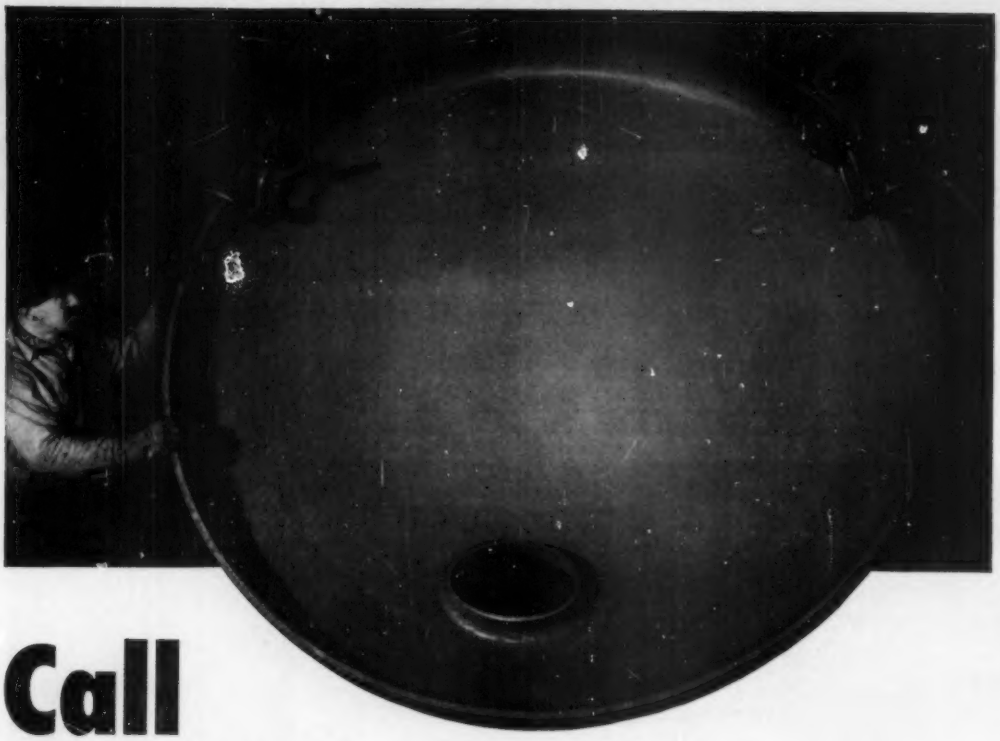
HYDRAULIC POWER BY VICKERS

BALANCED VANE TYPE PUMPS

Smaller Pines Benders use this Vickers Single Stage Vane Type Pump (for 1000 psi continuous operation). Hydraulic balance eliminates bearing loads caused by pressure, assuring longer life.



Larger Pines Benders have this Vickers Two Stage Vane Type Pump (for 2000 psi continuous operation) which has two hydraulically balanced pumping cartridges in one compact housing.



Call Bethlehem for Flanged-and-Dished Products

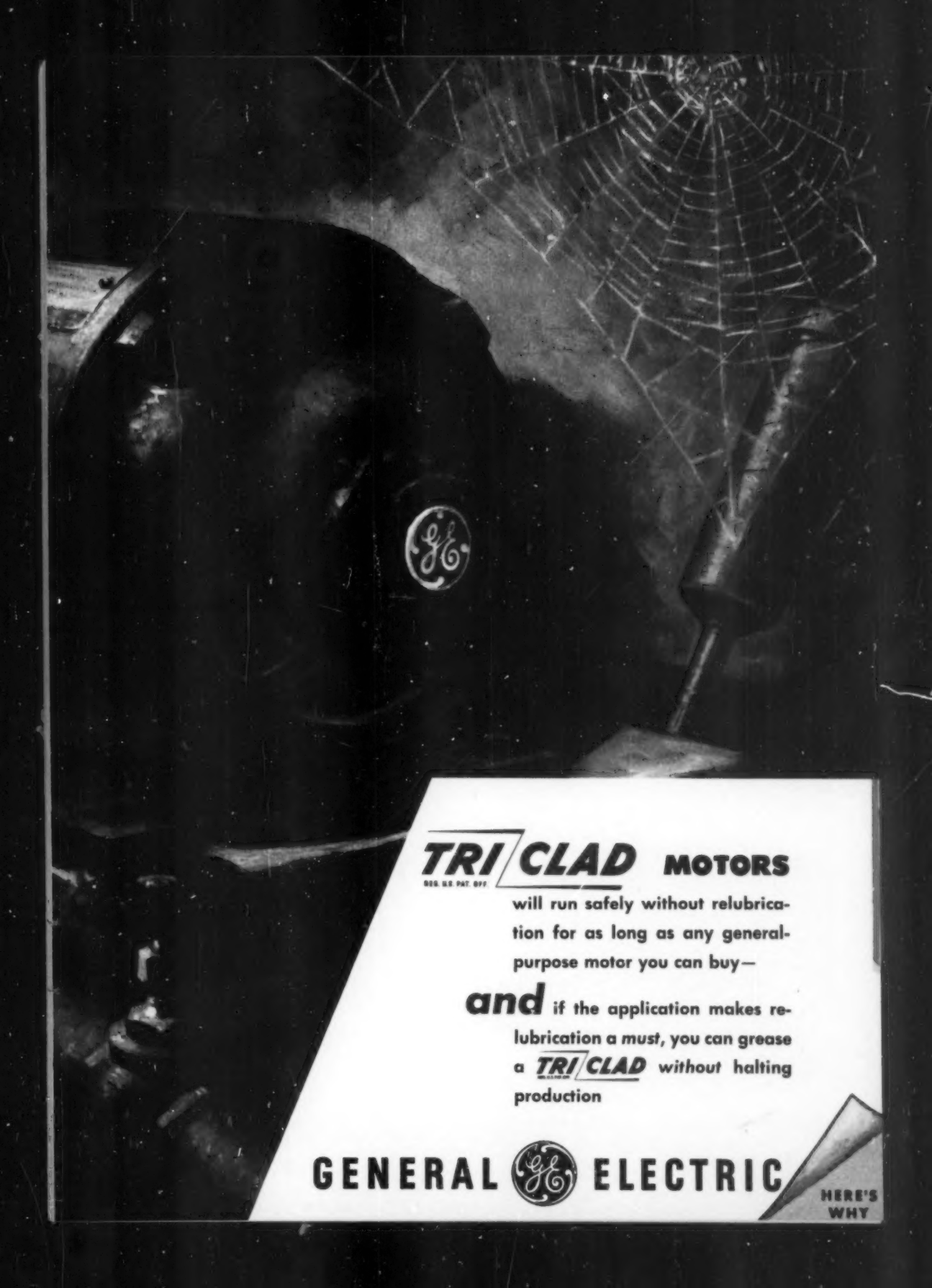
HEADS
Flanged-Only
Standard Flanged-and-Dished
Shallow Flanged-and-Dished
ASME Code Flanged-and-Dished
Elliptical
Tank-Car
Obround-Tank
Double-Dished

Standard Manholes and Covers
Hand Holes and Covers
Flue Holes
Collar Flanges
Pipe Flanges

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL


TRI/CLAD MOTORS
REG. U.S. PAT. OFF.
will run safely without relubrication for as long as any general-purpose motor you can buy—
and if the application makes relubrication a *must*, you can grease a TRI/CLAD *without* halting production
GENERAL ELECTRIC
HERE'S WHY

TRI CLAD MOTORS will run safely without relubrication for as long as any general-purpose motor you can buy—

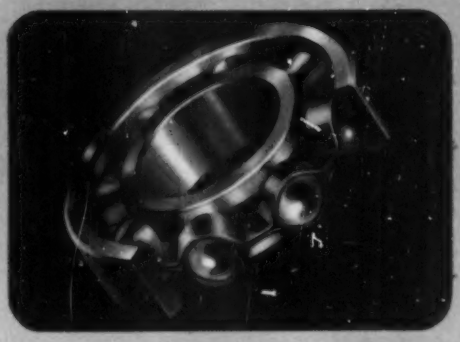
Tri-Clad extra lubrication "protection" can save you money because:

1. Tri-Clad's oversize grease reservoir and the heaviest standard-service bearings mean you do not have to bother with greasing between motor check-ups.

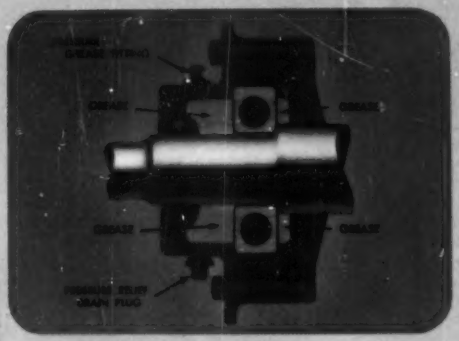
2. When relubrication is needed on those tough applications, you can grease a Tri-Clad without interrupting production-line operations.

Tri-Clads are grease-gun easy to lubricate *on the job*. Moreover, a Tri-Clad motor will run safely where an ordinary motor would fail. Chances are you'll be spared the cost of a "special" motor.

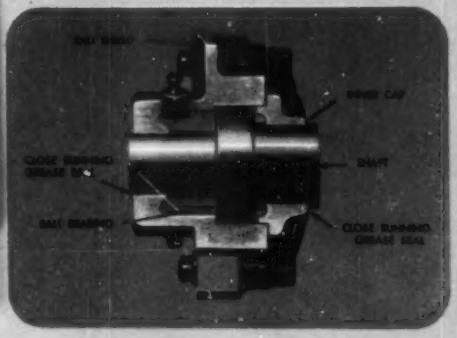
YOU BE THE JUDGE! The best way to prove to yourself that Tri-Clad gives you the most for your motor dollar is to contact your local G-E office. Tri-Clad stocks are complete. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*



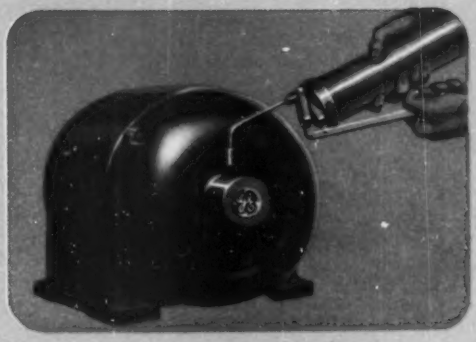
1 **EXTRA BEARING PROTECTION** — Tri-Clad gives you extra bearing protection because heaviest standard-service bearings are carefully selected to withstand severe loads for long periods.



2 **EXTRA GREASE** — Four times the ordinary amount of grease is packed into the large Tri-Clad grease reservoir. Since bearing life depends on grease, this means that Tri-Clad motors will run safely for years — for as long as any general-purpose motor you can buy.



3 **SEALED-IN BEARINGS** — Bearings and grease are completely sealed in a cast housing with *long running* seals for extra protection from dirt, dust, and lubricant leakage.



4 **PRESSURE-RELIEF GREASING** — An efficient system of pressure-relief lubrication (with standard fittings) enables a Tri-Clad motor to be quickly and easily greased on the job when and if it's needed.

GENERAL ELECTRIC

MR. PRODUCT DESIGNER

Count the advantages of Monsanto plastics in this one product.

Some of these—or the many others not mentioned here—might apply to your product.

Why not check with Monsanto today?

We'll gladly work with you.

"Egg-crate" grill of fluorescent lighting fixture is molded exclusively of Monsanto's Lustrex styrene by Bernard Edward Company for Leader Electric Manufacturing Corp., both Chicago.

"Our 'light' was hiding under a bushel... until we banished habit-itis"

says WALTER GLASS,

Leader Electric Manufacturing Corp., Chicago

"This new-product success story might never have been told, if we hadn't side-stepped 'habit-thinking'," Mr. Glass continues. "But by avoiding 'habit-itis' we were able to successfully pioneer a new 'egg-crate' fluorescent lighting fixture made with louvres of Monsanto Lustrex styrene."

When Leader Electric programmed an improved lighting fixture, they investigated dozens of materials—including plastics. After extensive materials-tests, they selected Lustrex for the louvres, exclusively, because of its remarkable lighting qualities, ease of molding, excellent physical properties, and low cost.

Leader discovered, for instance, that the translucency of Lustrex gives *more* light, more diffusion, and less glare than materials they had previously used. It blends more pleasingly with ceiling colors. Its versatility and ease of molding in large sections permits a necessarily intricate mold design.

Fabricating, painting, and assembly operations are eliminated, work areas reduced. And for economy, safety, and durability in shipping and in use, Lustrex is light-in-weight, shatterproof, dimensionally stable. In addition, material costs are substantially reduced.

Hundreds of manufacturers in scores of different industries are finding that the varied and versatile properties of Lustrex styrene and Monsanto's many other plastics can help improve their products—or lower their costs. You'll want to investigate the possibilities of plastics for your products, so write Monsanto today—or use the handy coupon.

Lustrex: Reg. U. S. Pat. Off.

For your convenience →

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CHEMICALS—PLASTICS

SERVING INDUSTRY... WHICH SERVES MANKIND

MONSANTO CHEMICAL COMPANY
Plastics Division, Dept PEP 28, Springfield 2, Mass.
Please send me "What Monsanto Plastics Can Do For You."

Name & Title _____

Company _____

Products Manufactured _____

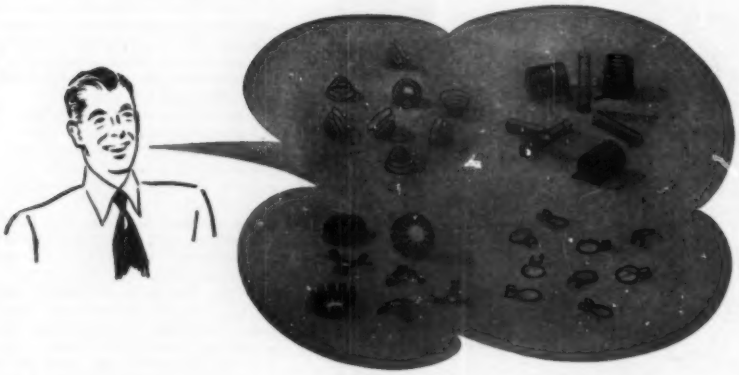
Address _____

City, Zone, State _____

.....and we

"QUOTE"

"It matters little to the ultimate user of a product whether or not a spring is employed in its proper functioning. But to the manufacturer, the one who is deeply concerned with the quality of his product, the resilient member—the spring—stands out as the very heart of the mechanism."



Your requirements, too!

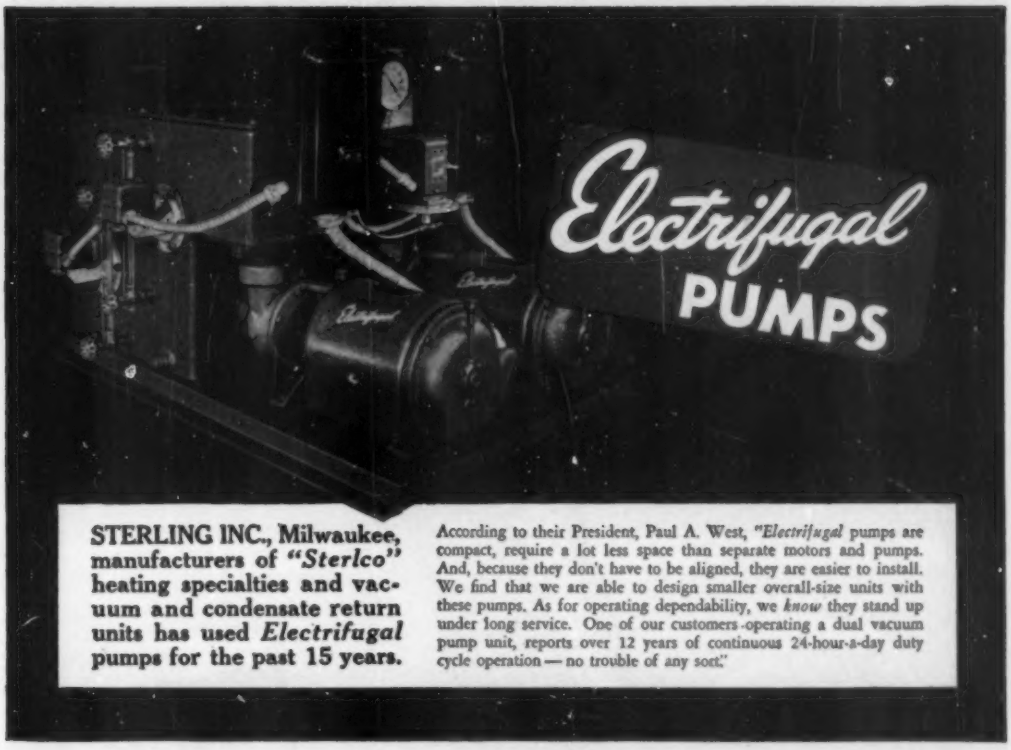
SMOOTH ACTING

GIBSON-SPRINGS

CLIPS · SMALL STAMPINGS
CLAMPS · WIRE FORMS

The William D. Gibson Co.

DIVISION OF ASSOCIATED SPRING CORP.
1800 CLYBOURN AVE., CHICAGO 14, ILL.



STERLING INC., Milwaukee, manufacturers of *"Sterlco"* heating specialties and vacuum and condensate return units has used *Electrifugal* pumps for the past 15 years.

According to their President, Paul A. West, *"Electrifugal* pumps are compact, require a lot less space than separate motors and pumps. And, because they don't have to be aligned, they are easier to install. We find that we are able to design smaller overall-size units with these pumps. As for operating dependability, we *know* they stand up under long service. One of our customers operating a dual vacuum pump unit, reports over 12 years of continuous 24-hour-a-day duty cycle operation — no trouble of any sort."

Save Space..Cut Design Costs

WITH THESE ALLIS-CHALMERS PUMPS!

2. COOLANT PUMPS

Foot-mounted, submerged, and side wall mounted types... sizes from 1 in. x ¾ in. to 1½ in. x 1½ in. Unit shown is side wall vertically mounting type — used extensively on broaches, drills, lathes, milling machines. Check coupon for information on complete Allis-Chalmers Coolant Pump line.

3. PEDRIFUGAL PUMPS

Pedestal-type pump that can be direct or *Texrope* V-belt driven for varying capacity and head. Five sizes handle all general pumping requirements to 500 gpm, heads to 110 ft. Pre-lubricated bearings require no further attention for three to five years. Check coupon for more information about *Pedrifugal* pumps.

Texrope, Electrifugal and *Pedrifugal* are Allis-Chalmers Trademarks.

ALLIS-CHALMERS

ALLIS-CHALMERS, 1002A SO. 70 ST, MILWAUKEE, WIS.

Gentlemen: Please send me information on:

- ☐ *Electrifugal* Pumps — 52B6140A
- ☐ Coolant Pumps — 52B6975
- ☐ Pedrifugal Pumps — 52B6691

Name

Title

Firm

Address

City State

A-2958

SOLD AND APPLIED BY AUTHORIZED DEALERS, AND DISTRICT OFFICES THROUGHOUT U. S., SERVICED BY CERTIFIED A-C SERVICE SHOPS

Everywhere—hats are off to the SIZE-MARK on PARKER-KALON Socket Head Cap Screws

TOOL CRIB BOSSES
welcome it because sorting is made so much easier and quicker . . . a glance at the head of a P-K Screw immediately tells you its size.

ASSEMBLY WORKERS
are all for it because sizes are always issued correctly. The Size-Mark prevents delays, helps them make better time on the job.

APPRENTICES
cheer the Size-Mark on P-K Screws because it protects them from errors . . . enables them to learn sizes faster and do a better job.

SALES MANAGERS, TOO
hail the Size-Mark on P-K Screws. It's a definite sales advantage because it saves time for customers' service men in reassembly.

And the GEAR GRIP† prevents *slipping* — even when fingers are oily! Send for samples . . . see for yourself how P-K* Size-Marked Socket Head Cap Screws can put your product ahead, assembly-wise and sales-wise. Parker-Kalon Corporation, 200 Varick Street, New York 14, N. Y.

NEW . . . . . Size-marked Engineered Hex Keys

Key size, and corresponding socket set and cap screw sizes, are clearly stamped on the arm of Parker-Kalon Engineered Hex Keys. P-K Hex Keys are again available in attractive, compact steel cases with easy-to-use key island (Set No. 111), and in durable plastic pouches (Set No. 45).

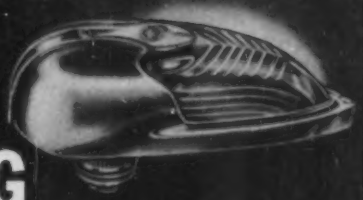
P-K TRADE MARK

PARKER-KALON* *cold-forged* SOCKET SCREWS

SIZE-MARKED SOCKET HEAD CAP SCREWS • GROUND THREAD SOCKET SET SCREWS • FLAT HEAD SOCKET CAP SCREWS
STRIPPER BOLTS • PIPE PLUGS • HEX KEYS • AVAILABLE EVERYWHERE THROUGH ACCREDITED DISTRIBUTORS

*TRADE MARKS REG. U.S. PAT. OFF. †U.S. DESIGN PAT. NO. 125,409

DIE CASTING



...IF YOU WANT TO SWING OVER TO SPEEDIER OUTPUT, LOWER UNIT COSTS

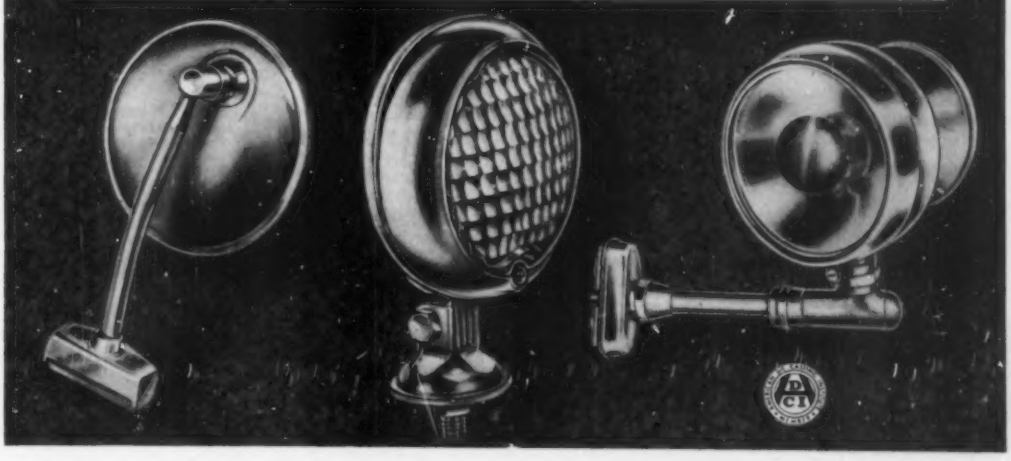
CASE HISTORIES FROM MT. VERNON FILES

. . . and effect greater savings in effort and raw materials than you've ever achieved before.

To take an example: All the housings for Yankee "Turnmaster" Automobile Directional Signals, Back-up Lights, Side-view Mirrors, and Mirror-Spotlight combinations are die cast—for however intricate their shapes, they can be accurately produced with exceptional rapidity. Apertures for Universal swivel ball joint mountings, bolt holes, decorative embossing, are all obtained in a single operation — instantly, as the die closes. And Mount Vernon produces each casting so "clean" that machining is virtually eliminated and high quality finishing simplified.

Here's economy—without sacrifice of strength or appearance. Here's the means to gain ground in today's competitive market.

Profit by considering the many advantages of die casting before scheduling your next production procedure—and consult with us. We feel confident we can show you the right direction to increased production . . . with savings "at every turn."



NYLON PLASTIC KEEPS BELL HELICOPTER TRANSMISSION WORKING OVER 40 TIMES LONGER

Combination of economy and operating properties, found only in molded Du Pont nylon, solves problem of making efficient bearing cages

INCREASE in service life of transmission from *25 hours to well over 1000 hours*—that's the success story of molded nylon bearing cages used in the Bell helicopter transmission.

Three years ago Bell Aircraft began assembly-line production of its Model 47B helicopter. They met with trouble in the bearing cages of the transmission. It was found impossible to get over 25 hours of reliable service life from any standard anti-friction bearing small enough for the job.

THE NYLON BEARING CAGE is a key part of this improved pinion assembly, which has increased the service life of the Bell helicopter transmission from 25 to over 1000 flight hours. (Bearing cage molded by Peerless Molded Plastics, Inc., Toledo)

A long search was begun for a satisfactory part to conform with Bell's exacting specifications. Some materials cost too much, others could not meet all service requirements, particularly for the lower stages, which bear the brunt of the load. Then they tried molded nylon cages, and nylon was the answer. Since the advent of nylon cages, no bearing failures have been reported even in helicopters with over 1000 flight hours.

Nylon's properties solved the problems encountered in this application. Its light weight keeps centrifugal loads to a minimum. Its excellent bearing properties call for the barest lubrication. Hard and tough, nylon absorbs shocks and vibrations. And it's readily and economically molded in simple or intricate shapes, and to the closest tolerances. It maintains dimensional stability even in light sections.

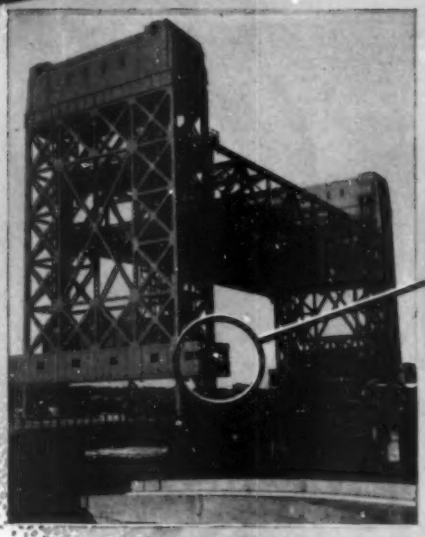
Nylon's outstanding combination of properties may help you solve design and production problems at actual cost savings. For more information on nylon and other Du Pont plastics, write today for free literature. E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Plastics Sales Offices: 350 Fifth Avenue, New York 1, N. Y.; 7 S. Dearborn Street, Chicago 3, Ill.; 845 E. 60th Street, Los Angeles 1, Calif.

DU PONT
REG. U. S. PAT. OFF.
PLASTICS
Better Things for Better Living
. . . through Chemistry

this job...

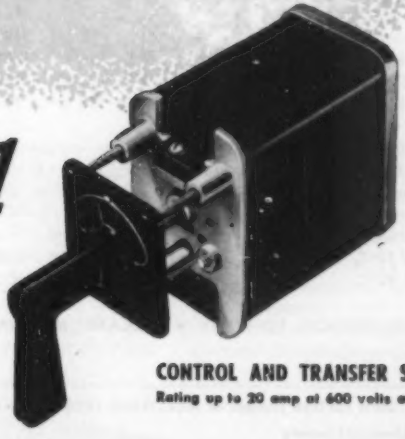
POWER TRANSFER FOR LIFT BRIDGE

STICKEL MEMORIAL BRIDGE, NEW JERSEY STATE HIGHWAY DEPARTMENT, OVER PASSAIC RIVER BETWEEN NEWARK AND HARRISON, NEW JERSEY.



On this 222-foot, 3000-ton span General Electric Type SB-1 control switches are used to transfer operation to the auxiliary power system, select instrument readings, and control the bridge locking mechanism.

... easily done with the SB-1



CONTROL AND TRANSFER SWITCH
Rating up to 20 amp at 600 volts a-c or d-c

Standard parts and the simple basic design of the SB-1 mean longer life and low initial cost to you. There's a *standard* SB-1 for most jobs, and they're ready on four weeks' delivery. Easy to order, too. A variety of attractive switch handles, and watertight, dust-tight, oil-immersed, fabricated metal, or explosion-proof housings are available to fit your particular installation problems. Mount on panels ⅛ to 2 inches thick. Switch shown at right is 8¼ inches over-all, 2¾ inches wide, 4¼ inches high. Why not try an SB-1 on your particular control problem? For further details see your G-E sales representative and write for Bulletin GEA-4746. *Apparatus Department, Section 856-71, General Electric Company, Schenectady 5, New York.*

GENERAL ELECTRIC

Can You Use a HEAVY liquid?

Can you use a heavy liquid that has contributed greatly to simplifying design and fabrication of certain products?

Acetylene tetrabromide is an unusually heavy liquid with a specific gravity of 2.95. It is stable in dry air in the absence of sunlight and, when sealed in an opaque container, will not break down.

Acetylene tetrabromide is comparatively inexpensive and finds wide use as a gauge fluid and as the movable part in vibration dampeners.

GIVE A SEARCHING LOOK at the properties of acetylene tetrabromide. Then, if you desire further information or technical service, write or wire Dow.

$C_2H_2Br_4$ →

Properties:

Clear, colorless liquid with a mild sweet odor.

Specific gravity at 25/25°C.	2.953
Pounds per gallon at 25°C.	24.57
Boiling point at 15 mm. Hg	119°C.
Freezing point	0.0°C.
Fire point	None
Flash point	None

Solubility, grams per 100 grams solvent:

Alcohol at 25°C.	∞
Carbon Tetrachloride at 25°C.	∞
Chloroform at 25°C.	∞
Ether at 25°C.	∞
Water at 30°C.	0.065
Water at 80°C.	0.28

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

Send for free sample of ACETYLENE TETRABROMIDE

The Dow Chemical Company
Dept. 2-H
Midland, Michigan

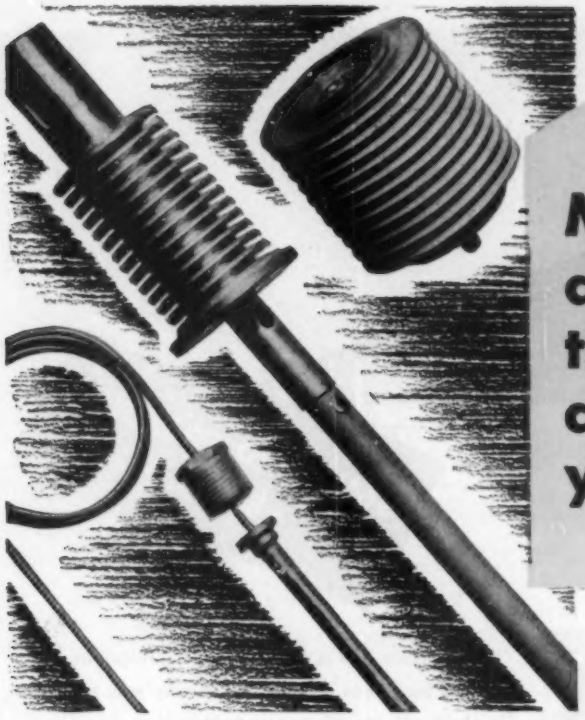
Name _____ **Title** _____

Company _____

Address _____

City _____ **State** _____

DOW
CHEMICALS
INDISPENSABLE TO INDUSTRY AND AGRICULTURE



Made as YOU want them— at savings you want!

FULTON SYLPHON
Stainless Steel Bellows Assemblies

TYPICAL APPLICATIONS

- Thermostatic devices
- Pressure controls
- Hydraulic mechanisms
- Valves
- Shaft seals
- Recording instruments
- As expansion chambers—and many more uses.

If you use, or plan to use stainless steel bellows assemblies, we can produce exactly what you want—save you time and money, too!

Designing, producing, assembling and testing them calls for the highest skill. Our personnel is expert in every phase—knows every "trick" in working with stainless steel. And our complete facilities can produce the most intricate assemblies, in any quantity, to meet your schedules.

See how that saves for you! You get assemblies made to *your* specifications—to help your products perform at their best. You are relieved of all production worries. You need no costly overhead in personnel and equipment. You can count on us for a responsible, dependable source of supply.

Our engineers will gladly help you in designing what you require—work with you confidentially if you wish.

Find out how you can make savings on your stainless steel bellows assemblies requirements from start to finish. Write today for Bulletin GP-1200 that gives you further information, *and* ideas!

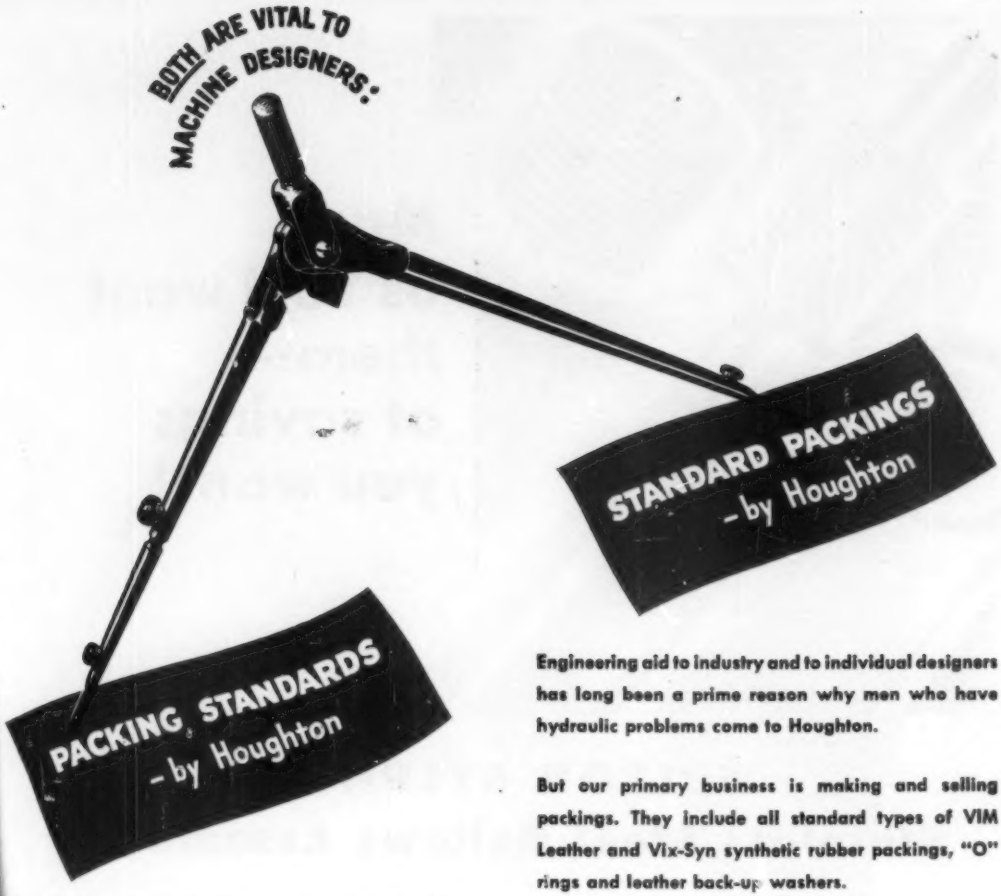
TEMPERATURE CONTROLS

FULTON SYLPHON DIVISION
Knoxville 4, Tenn.

Robertshaw-Fulton CONTROLS COMPANY

BELLOWS ASSEMBLIES • BELLOWS DEVICES

BRIDGEPORT THERMOSTAT DIVISION
Bridgeport 1, Conn.



Another Houghton "first"—a request to the packing industry from large users, which was promptly met by Houghton, and Houghton alone!

The Joint Industry Conference on packing standards has accepted our engineers' recommendations on how to promote interchangeability of packing sizes, reduce the number and adopt uniform "dash" numbers and coding for users' machine plates.

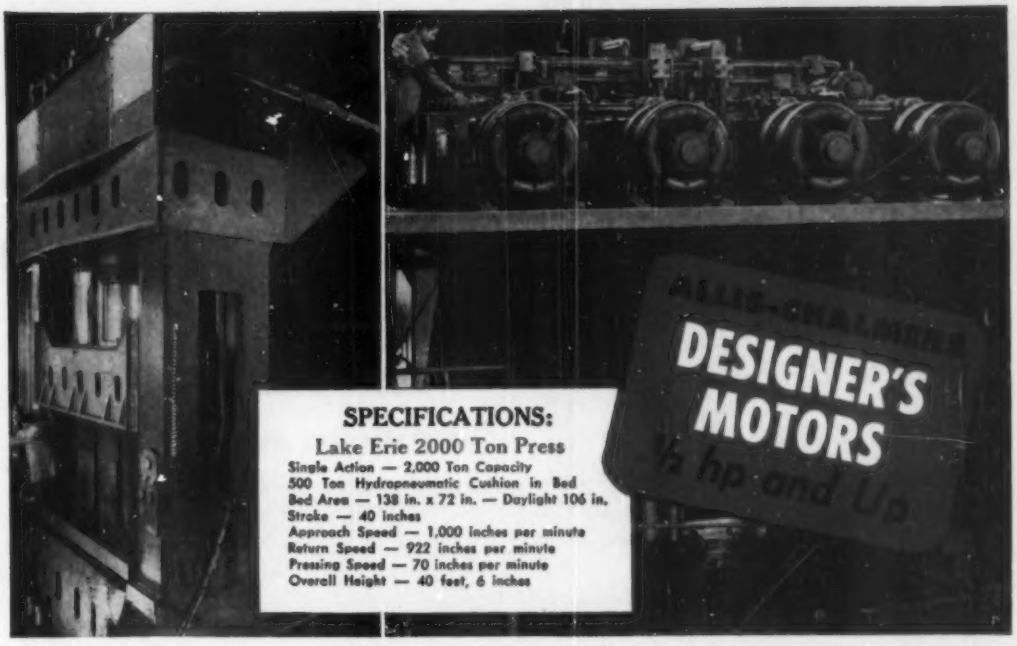
All of which should indicate that Houghton experience was of definite aid. Have you a copy of the "Packing Standards" free book which explains the whole project? Write for it.

Engineering aid to industry and to individual designers has long been a prime reason why men who have hydraulic problems come to Houghton.

But our primary business is making and selling packings. They include all standard types of VIM Leather and Vix-Syn synthetic rubber packings, "O" rings and leather back-up washers.

May we quote on your production needs, with the assurance that your individual packing problems will be painstakingly handled? E. F. Houghton & Co., Philadelphia 33, and all principal cities.

HOUGHTON'S VIM LEATHER and VIX-SYN PACKINGS



SPECIFICATIONS:

Lake Erie 2000 Ton Press

Single Action — 2,000 Ton Capacity
500 Ton Hydropneumatic Cushion in Bed
Bed Area — 138 in. x 72 in. — Daylight 106 in.
Stroke — 40 inches
Approach Speed — 1,000 inches per minute
Return Speed — 922 inches per minute
Pressing Speed — 70 inches per minute
Overall Height — 40 feet, 6 inches

2000 Ton Lake Erie Press uses 4 Allis-Chalmers 125 hp Motors!

NEED LARGE MOTORS for a giant 2000 ton press? ½ hp motors for a new bench lathe design? 10,000 hp motors?

You can probably select a *standard* Allis-Chalmers motor to fit your job.

GET THIS 4-POINT MOTOR PROTECTION WITH ALLIS-CHALMERS *Safety Circle* MOTORS

1 *Rigid Cast Iron Frame* completely surrounds all working parts . . . resists corrosion . . . gives added mechanical strength.

2 *Pre-lubricated Bearings* operate longer periods without attention. If motor is dismantled, it is recommended that bearings then be cleaned and repacked.

3 *Multiple Dipped and Baked* stator windings give *extra* protection against heat and moisture.

4 *Pressure-Cast Rotor* has no rivets or welds . . . there's nothing to rattle or shake loose.

BACK YOUR MOTOR UP WITH ALLIS-CHALMERS CERTIFIED SERVICE

An added reason for supplying Allis-Chalmers motors on your equipment is *Certified Service*. Your customers get this Allis-Chalmers service in every major industrial area. It is backed by factory methods and genuine A-C service parts.

And when you do specify Allis-Chalmers motors, be sure to order matching control as well.

SEND LITERATURE CHECKED BELOW:

ALLIS-CHALMERS, 1002A SO. 70 ST. MILWAUKEE, WIS.

Please send me:
Handy Guide for Electric Motors Bulletin 51B6052
Flange Motor Specification Sheet 51S7234
General Purpose Motor Controls Bulletin 1487132

Name .....

Title .....

Company .....

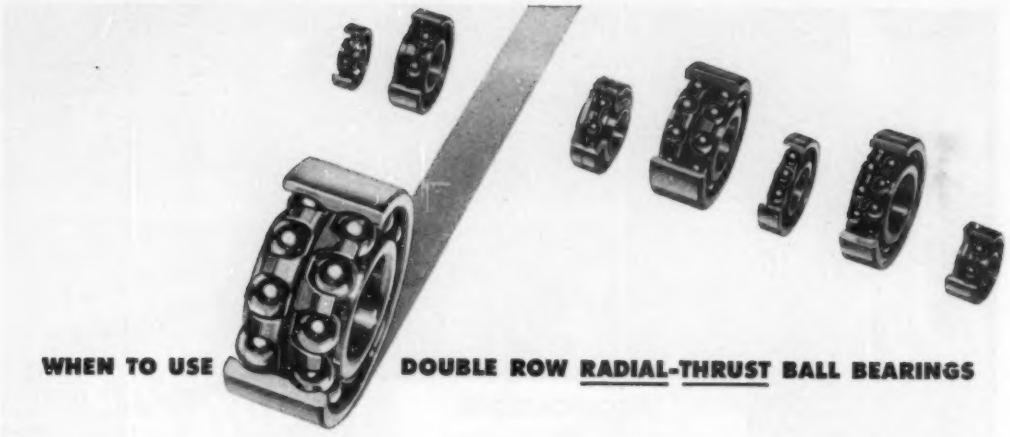
Street .....

City ..... State .....

A-2994

ALLIS-CHALMERS

SOLD AND APPLIED BY AUTHORIZED DEALERS, AND DISTRICT OFFICES THROUGHOUT U. S., SERVICED BY CERTIFIED A-C SERVICE SHOPS



WHEN TO USE DOUBLE ROW RADIAL-THRUST BALL BEARINGS

Heavy thrust or combined loads that have to be engineered into space too small for large diameter single row bearings are applications for compact Federal Double Row *Radial-Thrust* Ball Bearings.

Equal load distribution on each row of balls is insured by accurate alignment of both races—ground in a single setting for absolute concentricity and alignment to each other and to the bore.

Double angular contact takes the heavy radial loads as well as heavy thrust loads in either direction. For maximum rigidity and minimum deflection under all conditions of load, they may be preloaded in assembly if desired.

Our Catalog "K" describes all types of Federal Double Row *Radial-Thrust* Ball Bearings as well as companion series of double row *radial* bearings—shielded and sealed. Ball bearing selection charts among the 100 pages of engineering data will help you compute bearing loads, determine capacities at every speed, and select the type and size best suited to your application—from one of the most complete ball bearing lines. This 260-page book is yours for the asking. Write for a copy today.

THE FEDERAL BEARINGS CO., INC. · POUGHKEEPSIE, NEW YORK

Makers of Fine Ball Bearings

Quality since 1908

FEDERAL BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

"designed right—in the right plastic"

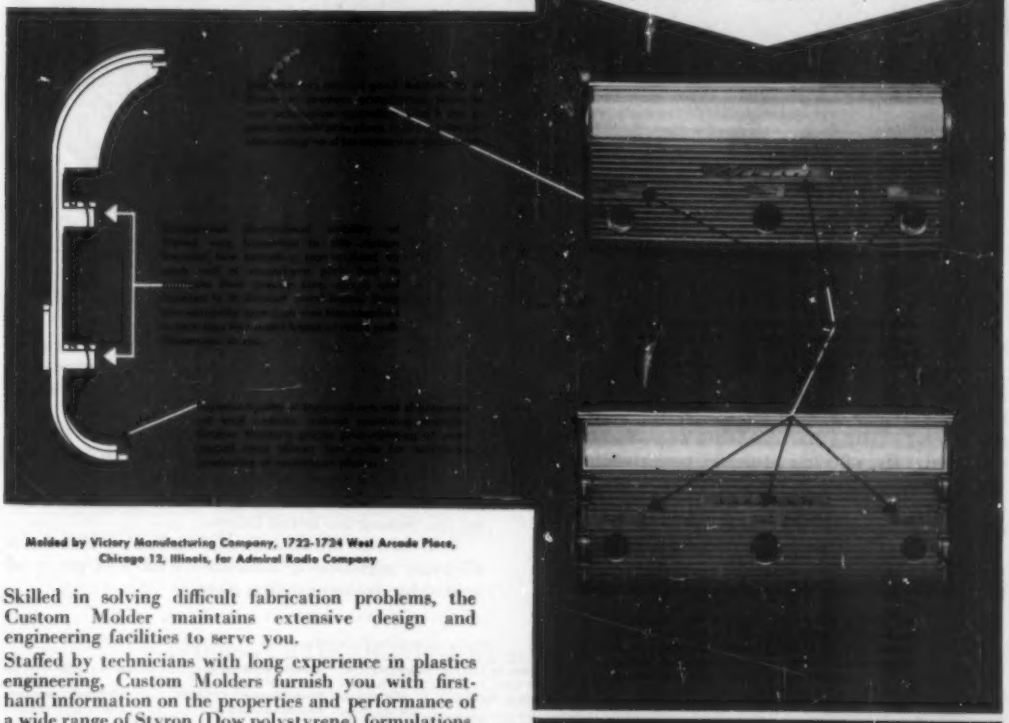
CUSTOM MOLDERS' KNOW-HOW plus

STYRON

solves another production problem!

ANOTHER CUSTOM MOLDING CASE HISTORY

Styron 666 was specified by the Custom Molder for the escutcheon plate on the Admiral Radio. Its selection was based on its excellent clarity . . . lower material cost and ease of molding which virtually eliminated machining and finishing operations for this attractive piece.



Molded by Victory Manufacturing Company, 1722-1724 West Arcade Place, Chicago 12, Illinois, for Admiral Radio Company

Skilled in solving difficult fabrication problems, the Custom Molder maintains extensive design and engineering facilities to serve you.

Staffed by technicians with long experience in plastics engineering, Custom Molders furnish you with first-hand information on the properties and performance of a wide range of Styron (Dow polystyrene) formulations.

It's your opportunity to get the most pieces possible per dollar spent. For the combination of Dow Research and the Custom Molders' designing know-how helps you to use to full advantage the excellent properties of Dow Plastics in your products. Write Dow today and let us put you in touch with a qualified Custom Molder, who will help solve your fabrication problem.

Plastics Division—Dept. SOT-18

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

DOW

New York • Boston • Philadelphia • Washington • Atlanta • Cleveland • Detroit • Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle • Dow Chemical of Canada, Limited, Toronto, Canada

SOFT GRAY CAST IRON
Tensile 30,000 psi

"OM" MEEHANITE Metal
Tensile 60,000 psi

STEEL CASTING—0.38%C
Tensile 73,500 psi

Combines the best properties of both cast iron and steel!

The description of Meehanite metal as "Bridging the Gap" between cast iron and steel was first written just 11 years ago. Since that time Meehanite castings have been providing designers, engineers, casting users, with a superior quality material. By offering unique combinations of the better properties of both iron and steel they have met many unusual demands and specifications.

The basic facts are revealed by the microstructures of the three materials. The ability to control both the quantity, size and form of the graphite as well as the nature of the pearlitic matrix of Meehanite metal, provides the means of predetermining engineering properties so as to meet exacting specifications.

Whether you need a soft, average-property iron (30,000 psi) or a tough, high-strength material providing uniform solidity, quality and dependability, specify Meehanite metal and consult any of the foundries listed below.

Ask for the Handbook of Meehanite Metals, a 67-page engineering manual which will prove of real value to any casting user.

Take Your Casting Problems To A MEEHANITE Foundry!

American Brake Shoe Co. — Mahwah, New Jersey
The American Laundry Machinery Co. — Rochester, New York
Atlas Foundry Co. — Detroit, Michigan
Banner Iron Works — St. Louis, Missouri
Barnett Foundry & Machine Co. — Irvington, New Jersey
E. W. Bliss Co. — Hastings, Mich. and Toledo, O.
Builders Iron Foundry Inc. — Providence, Rhode Island
H. W. Butterworth & Sons Co. — Bethayres, Pennsylvania
Continental Gin Co. — Birmingham, Alabama
The Cooper-Bessemer Corp. — Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co. — Portland, Oregon
Farrel-Birmingham Co., Inc. — Ansonia, Connecticut
Florence Pipe Foundry & Machine Co. — Florence, New Jersey
Fulton Foundry & Machine Co., Inc. — Cleveland, Ohio
General Foundry & Manufacturing Co. — Flint, Michigan
Greenlee Foundry Co. — Chicago, Illinois
The Hamilton Foundry & Machine Co. — Hamilton, Ohio
Johnstown Foundries, Inc. — Grove City, Pennsylvania
Kanawha Manufacturing Co. — Charleston, West Virginia
Kaukauna Co. — Milwaukee, Wisconsin
Lincoln Foundry Corp. — Los Angeles, California
E. Long Ltd. — Orillia, Ontario
Otis Elevator Co., Ltd. — Hamilton, Ontario
The Henry Perkins Co. — Bridgewater, Massachusetts
Pohlman Foundry Co., Inc. — Buffalo, New York
The Prescott Co. — Menominee, Michigan
Rosedale Foundry & Machine Co. — Pittsburgh, Pennsylvania
Ross-Meehan Foundries — Chattanooga, Tennessee
Shenango-Penn Mold Co. — Dover, Ohio
Smith Industries, Inc. — Indianapolis, Ind.
Standard Foundry Co. — Worcester, Massachusetts
The Stearns-Roger Manufacturing Co. — Denver, Colorado
Traylor Engineering & Mfg. Co. — Allentown, Pennsylvania
Valley Iron Works, Inc. — St. Paul, Minnesota
Vulcan Foundry Co. — Oakland, California
Warren Foundry & Pipe Corporation — Phillipsburg, New Jersey

"This advertisement sponsored by foundries listed above."

MEEHANITE

PERSHING SQUARE BUILDING • NEW ROCHELLE, N. Y.

YOU CAN BE **SURE**.. IF IT'S

Westinghouse

Life-Line's Space-miser compactness

SAVES PRODUCTION COSTS

This study in contrast shows how a Life-Line comes through in a pinch. For example: One manufacturer using conventional motors was forced to crowd two motors together. They did not quite fit, which meant removing a thin slice of cast iron from each motor frame. He'd been doing it for years . . . thought nothing of it.

Then, a designer saw the all-steel Life-Line. He tried it. Result? A step saved in manufacturing. Life-Line's ⅓ smaller size, for the same frame size and hp rating, fit easily with room to spare.

This compactness is a valuable asset when your design allows only limited space for the motor drive. (And saves money in reduction of shipping weight, too.) In addition, Life-Line "needs no further lubrication". You can install it in "hard-to-get-at" locations—and forget it!

These are but a few of the pluses a designer has with the Life-Line. Ask your Westinghouse representative for others. Ask him for a copy of B-3482, or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania.

J-21575

—— *If you figure LIFE-COSTS . . you'll figure LIFE-LINE* ——

NO DOUBT you've experienced it—the real pleasure in grasping a problem, wrestling with it a bit, and then coming up with a solution. The unusual electrical insulation part shown above is a good example. It illustrates the kind of problem that could arise in your plant—and wind up in our "Imagination Department."

To make the part, the Manufacturer wanted plenty of structural strength, dielectric strength, light weight, and resistance to moisture, heat, and corrosion—all wrapped up in a material that was easy to machine. Continental-Diamond studied the problem, used a little imagination, and came up with *two* different plastics—Laminated Dilecto Tubing for the threaded section, and Celoron for the molded, macerated ring.

It's a good example of imagination at work—but it's a better example of how you, too, can depend upon C-D to engineer the right plastic for your needs. For C-D has no "axe to grind." We can recommend from five basic plastics subdivided into a remarkably wide range of grades and combinations of grades to meet your requirements. For complete engineering help or fast delivery of any grade, call your nearest C-D office, any time.

DL-2-50

CELORON (Molded High-Strength Plastic)
MICABOND (Bonded Mica Splittings)
DIAMOND FIBRE (Vulcanized Fibre)
VULCOID (Resin Impregnated Fibre)
DILECTO (Laminated Thermosetting Plastic)

BRANCH OFFICES: NEW YORK 17 • CLEVELAND 14 • CHICAGO 11 • SPARTANBURG, S. C. • SALES OFFICES IN PRINCIPAL CITIES.
WEST COAST REPRESENTATIVE: MARWOOD LTD., SAN FRANCISCO 3 • IN CANADA: DIAMOND STATE FIBRE CO. OF CANADA, LTD., TORONTO 8

Continental-Diamond FIBRE COMPANY

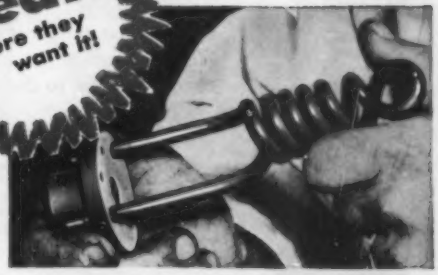
Established 1895. Manufacturers of Laminated Plastics since 1911—NEWARK 40 • DELAWARE

Steam on the beam

with "built-in" G-E CALROD* HEATERS

*Reg. U.S. Pat. Off.

Heat where they want it!



The Calrod heater is easily formed into a helical coil, cast into brass concentric to a ½-inch copper-tube coil, and the compact unit acts as a flash boiler.

Madewell Products, Inc. puts steam on the beam in their Electro Spray with "built-in" G-E Calrod heaters!

Like hundreds of other machinery manufacturers, Madewell Products, of Oakland, California, have found that the simplest, easiest, most reliable way to build heat into their product is with G-E Calrod heaters. And in two years there hasn't been a single heater failure in the field!

Many times the heat source is a vital part of your machine. Because of the many types of G-E heaters...because of the wide range of standard sizes, ratings, and sheath materials in which these heaters are available . . . they provide a ready, practical solution to almost every conceivable problem of building low-cost, efficient heat into machinery.

Before You Design your machinery or equipment for repetitive manufacture, contact your nearest G-E Apparatus Sales Office and get the recommendations of an Industrial Heating Specialist . . . it will pay you BIG dividends. And . . .

FOR THE NEW, FREE 1950 CATALOG, GEC-1005A, write us on your letterhead. And, if you'll also tell us about your heating jobs, we'll send you application bulletins to help you select and correctly apply the right heaters to give you heat *where* you want it . . . *when* you want it . . . and in the *amount* you want it. ***Sect. 720-19, Apparatus Dept., General Electric Co., Schenectady 5, N. Y.***

The Madewell Electro Spray, generates superheated steam which blasts particles of insecticide into the air for prolonged suspension with increased killing effects.

GENERAL ELECTRIC

720-19

new

FLEXIBLE HOSE

made from

. . . CARPENTER STAINLESS No. 20

This length of 1½" I.D. (.025" wall) flexible hose is the first of its kind, made from Carpenter's super corrosion-resistant Stainless No. 20.

This new hose will be particularly useful in applications where full corrosion resistance must be combined with flexibility . . . such as on equipment which vibrates, and where connections are used between movable parts or machines. Fluid line connections, and mechanical parts which must flex, are additional uses being developed.

Present size range of Carpenter Stainless No. 20 Flexible Hose is from 1" to 2⅝" I.D. Standard pipe size nipples can be welded to the ends, as shown here.

For technical data and recommendations on use of this new flexible hose, write to Carpenter's Engineering Department outlining your problem. A bulletin describing the corrosion-resisting properties of the material will be sent upon request. Just write a note on your company letterhead and ask for the Carpenter Stainless No. 20 Bulletin.

THE CARPENTER STEEL COMPANY • Alloy Tube Division
121 Springfield Road • Union, New Jersey

Export Department: 233 Broadway, New York 7, N.Y. "CARSTEELCO"

Carpenter

STAINLESS TUBING

"MORE THAN CORROSION RESISTANCE"

AUTOMATIC SHEAVES

WILLIAMS TOOL COMPANY, Brantford, Ontario, Canada selects Texrope Automatic Sheave for Pipe Threading Machines!

Give Efficient, Accurate Machine Tool Speeds!

HERE'S ANOTHER EXAMPLE of the versatility of *Texrope* Automatic Sheaves! Instantly *stepless* speed variations were required on these pipe threading machines to match the diameter and type of material being threaded.

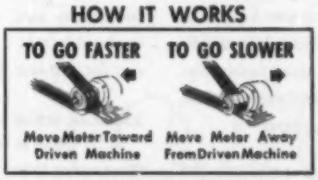
After considering many other means, Williams Tool Company installed a 2-groove R Section Vari-Pitch Automatic Sheave with 5.25 in. to 10.0 in. pitch diameter and a 7.2 in. pd companion sheave with clutch built into the hub.

This combination, plus a four-speed transmission gives them stepless speeds of 5.95 rpm to 34.7 rpm. And, because of the small size of the drive, it mounts in the small available space without change in machine design!

GET BROAD APPLICATION

Vari-Pitch Automatic sheaves can replace almost any standard sheave on drives from 1½ to 40 hp (special to 60 hp) . . . will give you *stepless* speed changes in a matter of seconds . . . overall speed ratios of as high as 2 to 1.

HOW IT WORKS



CHANGE SPEED WITH ONE HAND WHILE MOTOR IS RUNNING

For complete information on diameters and number of grooves, send coupon or check with your nearest A-C Sales Office or Authorized Dealer.

Vari-Pitch and *Texrope* are Allis-Chalmers trademarks.

ALLIS-CHALMERS

ORIGINATORS OF THE MULTIPLE V-BELT DRIVE FOR INDUSTRY

MAIL COUPON FOR HELPFUL LITERATURE:

ALLIS-CHALMERS, 1002A SO. 70 ST. MILWAUKEE, WIS.

Please send me the literature checked below:

☐ 1. *Vari-Pitch* Automatic Sheaves — Section 20-P-50 (Part 4)

☐ 2. Handy Guide for Quick Selection of standard *Texrope* Drives — Bulletin (2086051)

Name .....

Title .....

Firm .....

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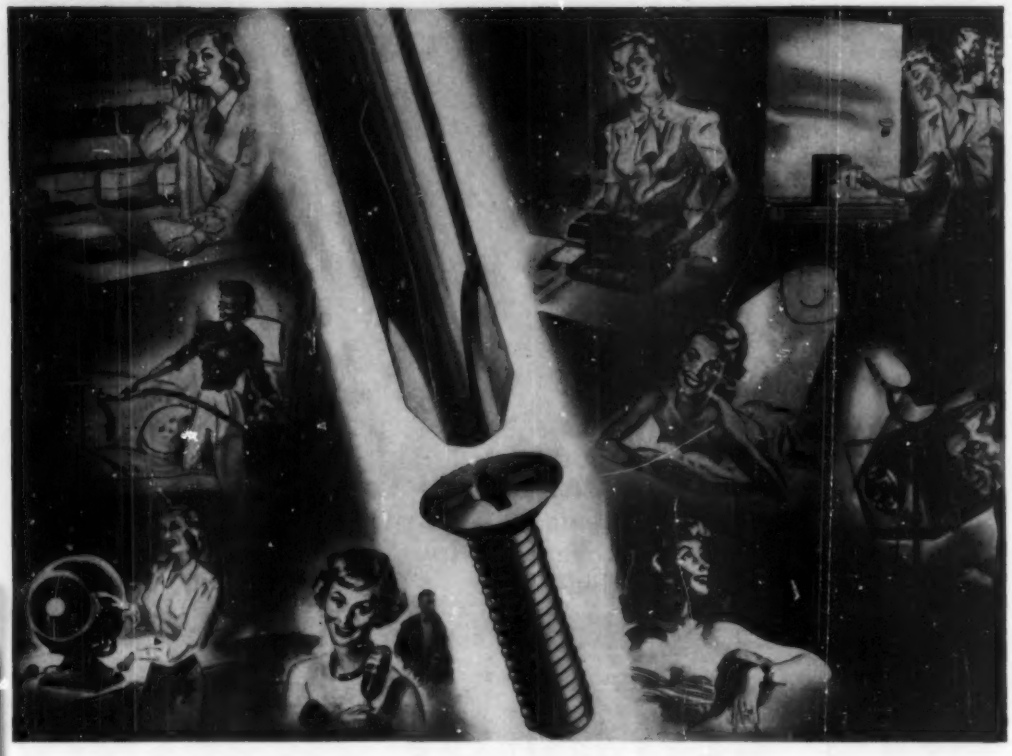
City ..... State .....

A-2970



Top Products in Every Line
Cut Costs and Build Sales
with AMERICAN PHILLIPS SCREWS

HOW THEY CUT COSTS: From vacuum cleaners to vending machines; from trucks to office appliances and suntan lamps . . . manufacturers use American Phillips Screws to speed up production, stop spoilage, and cut unit-costs. For these modern fastenings banish fumbling, crooked driving and scarred surfaces . . . *cut assembly time as much as 50%.*

HOW THEY BUILD SALES: On any product, the crossed-recess of American Phillips Screws is a "green light" to buyers who stop and look for an outward index of inward quality. They know that smooth-headed American Phillips Screws protect product-performance by staying tight and resisting vibration. Does *your* product have these two American Phillips advantages of cost-reduction and sales-promotion? No reason why it shouldn't . . . *for American Phillips Screws always cost least to use.* Write for proof.

AMERICAN SCREW COMPANY, Main Office: Providence 1, R. I.
Plants at Willimantic, Conn., and Norristown, Pa.
Warehouses at: Chicago 11: 589 E. Illinois St. Detroit 2: 502 Stephenson Bldg.

AMERICAN PHILLIPS *Screws*

ALL TYPES
ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

9 IMPORTANT ADVANTAGES IN FOOTE BROS.
NEW HYGRADE DRIVES

1 STURDY CONSTRUCTION
Gearing, shafts, bearings designed for heavy duty applications. Rigid housings maintain accurate alignment.

2 HIGHEST QUALITY FOR LONG LIFE
All materials are of highest quality. Simple gear assemblies—small number of working parts—large antifriction bearings all contribute to long life.

3 COMPACT DESIGN
Advanced design assures compact space-saving units in keeping with ratio of reduction, mechanical and thermal capacities required.

4 BETTER GEARS
New developments in manufacturing result in precision generated worm gear teeth which assure higher efficiency and greater load-carrying capacity. Worms are integral with worm shafts. Helical gears and pinions are shaved for full tooth contact.

5 GREATER DEPENDABILITY
Advanced engineering, improved design, plus accurate control of finest materials, modern heat-treatment, and manufacture—all assure higher quality, greater dependability.

6 SMOOTH PERFORMANCE—QUIET OPERATION
Precision manufacture results in uniform tooth action giving smooth, quiet transfer of torque.

7 TROUBLE-FREE OPERATION
Totally enclosed oil-tight and dustproof housings—ample lubrication for all moving parts. Maintenance is held to a minimum.

8 WIDE RANGE OF TYPES—SIZES—RATIOS
Hygrade Reducers are available in horizontal, vertical and Hytop types. Hytop vertical design permits long, unsupported shaft extensions. Ratios 4⅛ : 1 up to 4108 : 1 (higher where required.)

9 STANDARD RATIOS—PROMPT DELIVERY
To assure prompt delivery, standard stock ratios have been developed. These are available on short notice.

Here is a new line of enclosed worm gear drives that offers a wide range of sizes and ratios in horizontal, vertical and Hytop (long unsupported vertical shaft extension) types.

Newly designed cases assure greater compactness combined with rigid construction. New manufacturing processes result in precision generated worm gears giving high efficiency and load carrying capacity.

An engineering manual, HGA, gives complete rating and dimension tables, engineering data, etc. Mail the coupon for your copy.

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOT BROS.—LOUIS ALLIS GEARMOTORS

MAXI-POWER HELICAL GEAR DRIVES

HY-POWER WORM GEAR DRIVES

Foote Bros. Gear and Machine Corporation
Dept. W, 4545 S. Western Blvd.
Chicago 9, Illinois

Please send me a copy of Engineering Manual HGA.

Name.....

Company.....

Position.....

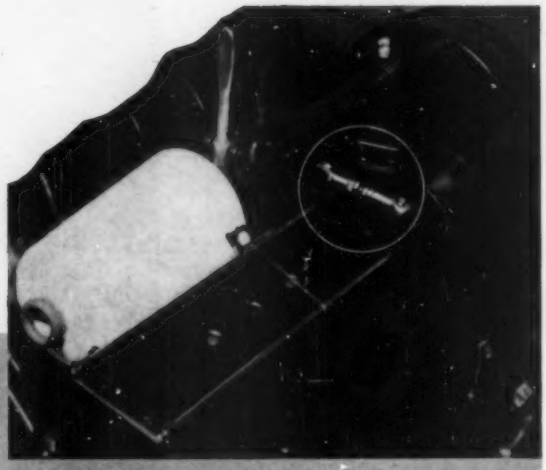
Address.....

City.....*State*.....

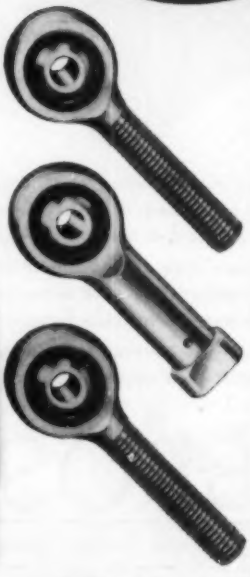
HEIM

SPHERICAL BEARING ROD ENDS

AT WORK



Foster Machine Co., Westfield, Mass.
Model 75 Pineapple Coning Machine



Complete catalogs are available upon request

The Heim Unibal Spherical Bearing, as its name indicates, consists of a single, hardened steel ball through which the shaft passes. This ball revolves in bronze bearing inserts which in turn are housed in the bearing body. A really amazing bearing principle, for which machinery manufacturers are finding more and more applications every day.

One such application of this bearing in the Heim Unibal Spherical Bearing Rod End is shown above in the Foster model 75. This machine is used for winding nylon, and rayon yarns to packages for full fashion knitting machines. The linkage for which the Heim rod ends are used, must be universally flexible, free-turning and ruggedly built to withstand considerable vibration.

Wherever motion is to be transmitted at varying angles, you too will find that Heim Unibal Spherical Bearings will prove to be more dependable, more efficient, and less costly.

THE HEIM COMPANY
FAIRFIELD CONNECTICUT

DESIGN IT "LIGHT"...

with

ELECTRUNITE

ELECTRICALLY-WELDED TUBING

Looking for a way to cut deadweight from your new or existing products . . . a way to make them easier to carry, easier to move, or easier to lift? Then consider carefully the use of Republic ELECTRUNITE Tubing from a structural standpoint.

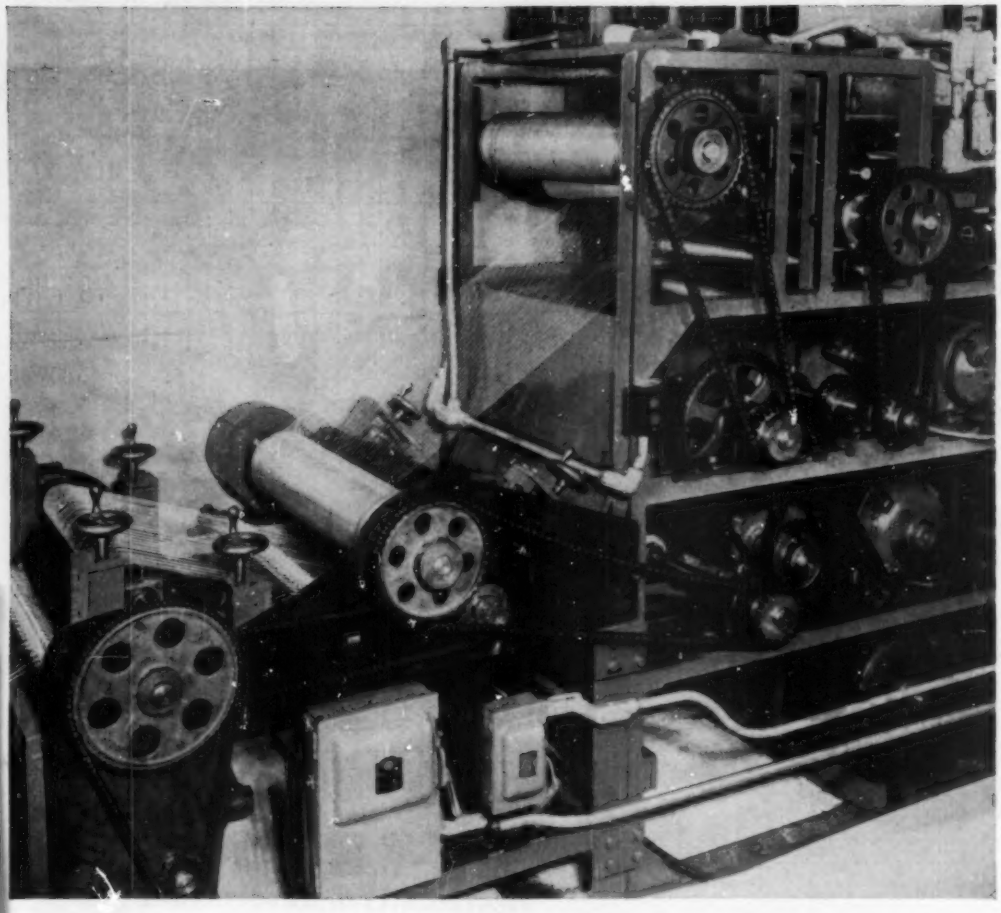
Modern ELECTRUNITE Tubing possesses an extremely high strength-to-weight ratio. There are practically no limits to its ability to take fabrication. It can be painted with ease and plated with a minimum of preparation. In many cases, its cost is less than that of other materials.

ELECTRUNITE Tubing is available in a full range of sizes, gages and analyses—both carbon and stainless steel. Write for complete information *today*.

REPUBLIC STEEL CORPORATION
STEEL AND TUBES DIVISION • CLEVELAND 8, OHIO
Export Department: Chrysler Building, New York 17, New York

REPUBLIC STEEL

Republic
ELECTRUNITE TUBING



Keeping Three Distinct Tension Zones SYNCHRONIZED!

Positive Whitney Chain Drives Help Fibre Bonding Machine Get Accuracy and Flexibility of Yarn Tension

The Dan River Mills "Fibre Bonded" process increases tensile strength of textile yarns by impregnating yarns with synthetic resins. This bonding machine, manufactured by Walter Kidde & Co. performs all operations . . . unwinding, impregnation, stretching, curing, and rewinding.

Yarn tension must be varied and strictly controlled for the different phases of the process and for different textiles. During the bonding process, pull is placed on the strands by driving each succeeding roll at a faster rate than the preceding roll.

To keep the three tension zones synchronized, *Walter Kidde & Co. uses an interconnected series of positive drive Whitney Roller chains* from the electric motor to the various rolls.

And for good reason... deeply seated in the sprockets, Whitney Roller chains deliver full power without speed loss or slippage from power sources to driven elements.

Their versatility and adaptability enables shafts to be driven clockwise or counter-clockwise from one power source simultaneously. They operate slack on short or long centers... do not impose excess loads on bearings.

Whitney Roller chains absorb shock loads without breakage assuring long life. They simplify maintenance when necessary because they can be put on or taken off without disconnecting shafts or gears.

No matter what power drive problem, Whitney Chains and Cut Tooth Sprockets... the all steel drives... meet requirements for positive power transmission.

Whitney Chain Drives... roller, silent, conveying chains and cut tooth sprockets ... are quickly available through a nationwide network of Whitney Distributors and Whitney Warehouses. Consult the one nearest you for prompt and efficient service. For Specialized engineering assistance write:

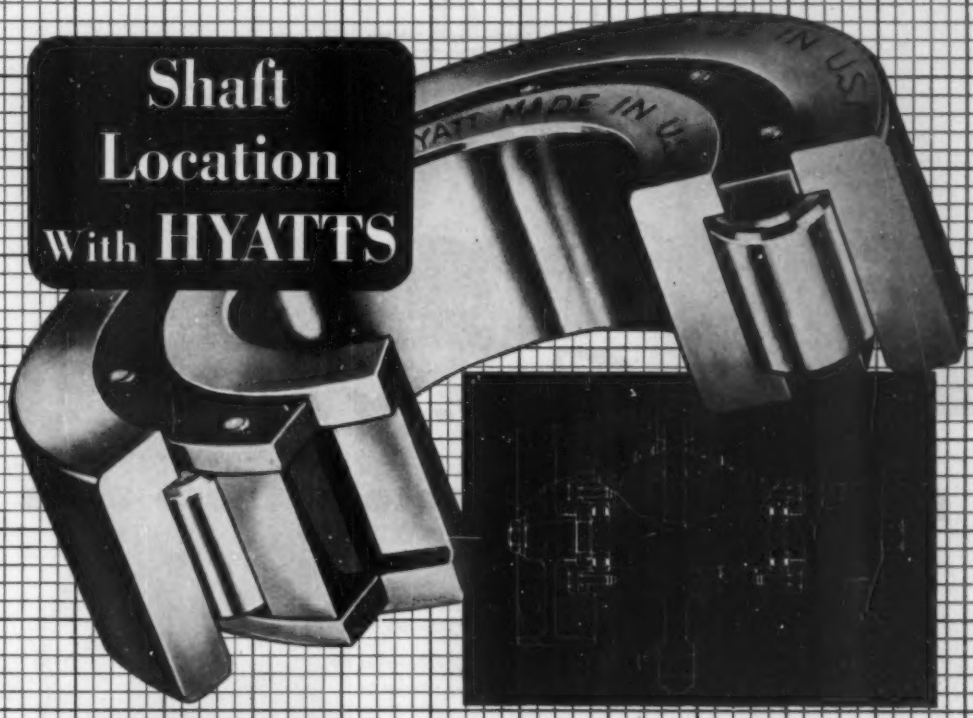
WHITNEY
Power Lines
ROLLER CHAIN DRIVES

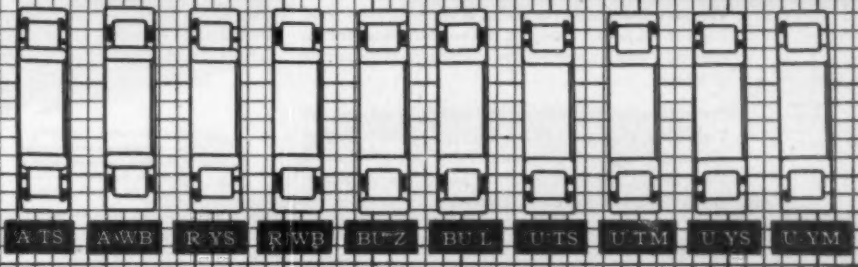
WHITNEY CHAIN & MFG. CO.

Division of Whitney-Hanson Industries, Inc.

304 HAMILTON STREET, HARTFORD 2, CONN.

Shaft Location With HYATTS





HERE is one of the ten basic types of Hyatt Hy-Load Cylindrical Roller Bearings, the "B-UL". It provides not only the high load capacity and long life of a cylindrical roller bearing but shaft location as well. It may be used on any application where two bearings are mounted opposed to locate shafts or gears in both directions.

The "B-UL" application illustrated is just one of the many ways in which the Hyatt Hy-Load Series Bearings can be used. Each of the ten different types of Hy-Loads have their special purposes and applications. Full information about all ten types of Hyatt Hy-Loads is in our catalog 547 . . . a complete engineering guide to radial bearing selection and use.

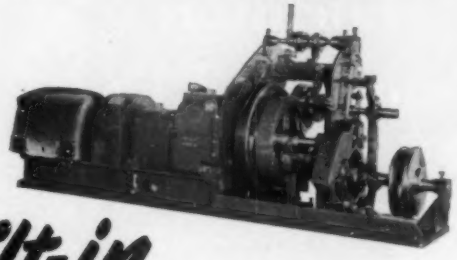
. . .

Write now for your copy. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

This 50-ton Manitowoc Speedcrane uses a Twin Disc Torque Converter to deliver power for smooth gear-shift-free lifting operations.

This electric-motor driven Johnson and Bassett spinning mule incorporates a Twin Disc Hydraulic Coupling in addition to three Twin Disc friction clutches.



Built-in preventive maintenance in these units

More and more manufacturers of heavy-duty powered equipment are designing preventive maintenance right into their units with Twin Disc Hydraulic Drives—Couplings, Torque Converters and Power Take-offs.

Hydraulic drives, by eliminating any direct connection between driving and driven parts, provide a cushion to absorb shock loads before they can become destructive. Vibration from engine or motor is dampened out. And these drives permit a smooth pick-up of the load from a dead stop—with no possibility of stalling out the engine or motor.

Preventive maintenance is an accomplished fact on Twin Disc Hydraulic Drive-equipped machinery. For complete information, write today for helpful literature. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

This 3-ton mine locomotive, shown partially assembled at the plant of The Ruth Company, employs a Twin Disc Hydraulic Power Take-off for smooth operation.

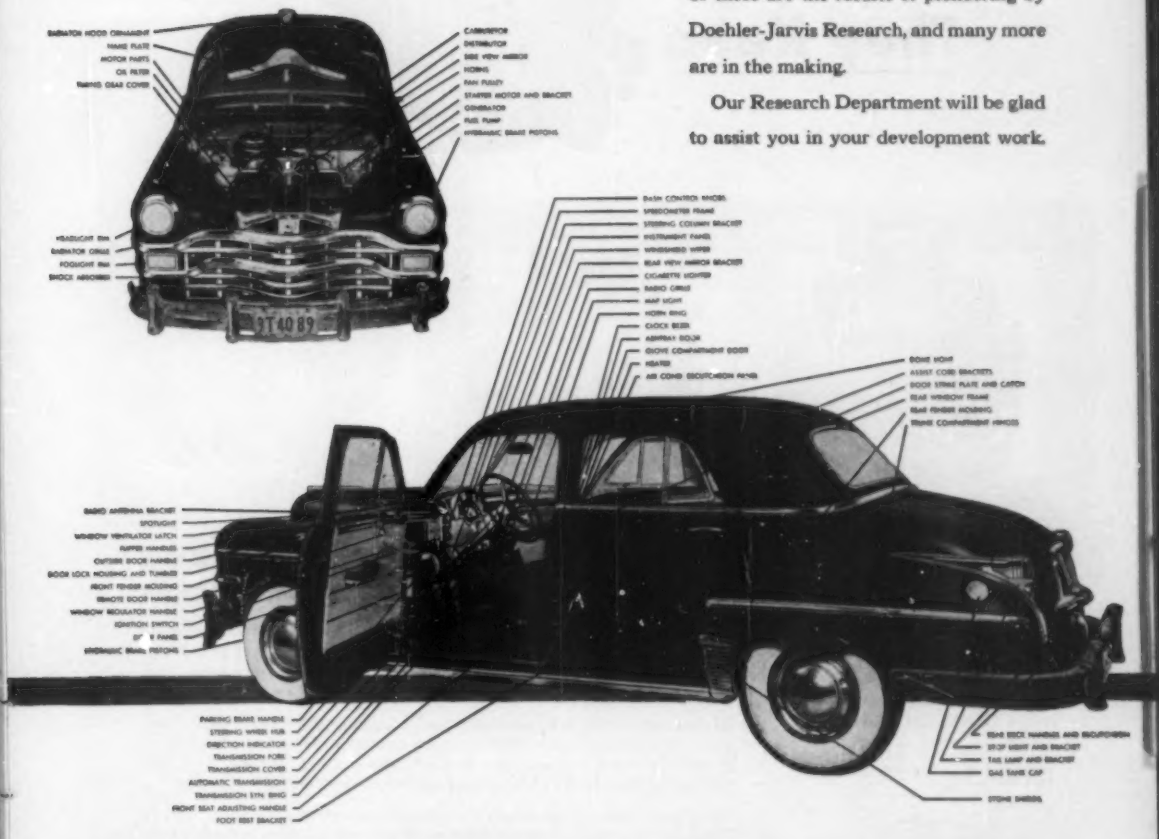
Twin Disc Torque Converters, which multiply engine torque up to five times, are used on Allis-Chalmers heavy-duty tractors.

SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

65
DIE CAST
APPLICATIONS
. . . and more to come

There are at least 65 die cast applications in current automobile models. Many of these are the results of pioneering by Doehler-Jarvis Research, and many more are in the making.

Our Research Department will be glad to assist you in your development work.



DOEHLER-JARVIS CORPORATION

The World's Largest Producer and Finisher of Die Castings

PLANTS AT: TOLEDO, OHIO · POTTSTOWN, PA. · BATAVIA, N. Y. · GRAND RAPIDS, MICH. · CHICAGO, ILL.

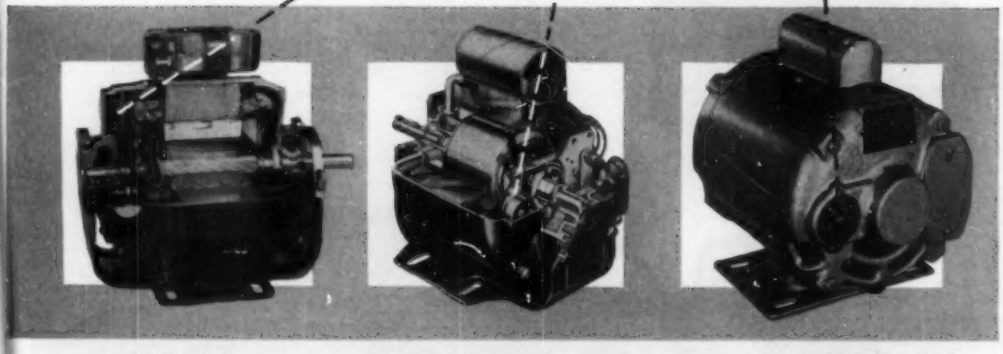
EXECUTIVE OFFICES: 386 FOURTH AVENUE, NEW YORK 16, N. Y.

You Can Tell Klixon Protectors Protect Motors

By The Company They Keep

Manual reset protector

Klixon automatic reset protector



HERE'S HOW KLIXON PROTECTION WORKS

CLICK!... IT'S OFF!

Should a motor become overheated and dangerously hot, the Klixon Protector snaps the power "off" preventing the motor from burning out.

CLICK!... IT'S ON!

When the motor cools to safety, the Klixon Protector snaps the power "on" automatically, or by pushing the red button when the manual reset type is used.

LEADING MOTOR MANUFACTURERS USE KLIXON PROTECTORS TO PREVENT MOTORS FROM BURNOUTS

Motor manufacturers everywhere extend the life line of their motors by installing Klixon Overheat Protectors into their products. Their experience proves that these foolproof protectors keep motors from overheating and burning out.

Motor users, too, are specifying and using motors with Klixon Protectors to assure dependable motor operation. They have found that protected motors do not burn out. This means that they save time and money by practically eliminating costly repairs and replacements.

Keep your motors operating . . . specify and use motors with built-in Klixon Protectors. Remember, too, that Klixon Protectors also provide overheat protection in transformers, solenoids, adjustable transformers and other equipment. The additional cost is low . . . pays for itself many times over by preventing burnouts.

KLIXON

Spencer Thermostat

Division of Metals & Controls Corporation

904 FOREST STREET, ATTLEBORO, MASSACHUSETTS

Know Your Plastics

IT MAY MEAN BETTER AND FASTER PRODUCTION... AT LOWER COST!

When you investigate plastics for your new or revised product and package designs, think first of BAKELITE Plastics. The BAKELITE family of products includes those plastics that are in greatest demand. This gives you a wide selection, all from one supplier. The chances are that you will find the one plastic that is best suited to your production facilities, and also the plastic that gives best qualities to your finished product at lowest possible cost.

This message deals with **"BAKELITE" PHENOLIC MOLDING MATERIALS**

1. GENERAL-PURPOSE PHENOLICS

These materials have widest utility, providing many desirable properties, preformability, ease of molding, and all-round serviceability at lowest cost. They come in blacks, browns, mottles, and made-to-order colors.

Typical uses: radio and television cabinets, bottle caps, wiring devices, automobile distributors.

2. IMPROVED IMPACT-RESISTANT PHENOLICS

These materials provide the excellent appearance of the general-purpose phenolics, and up to twice their resistance to mechanical shock. They are readily preformed, but may require special feeding devices on machines.

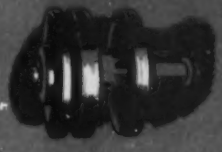
Typical uses: washing machine agitators, instrument cases, meter housings.

3. PREFORMABLE IMPACT-RESISTANT PHENOLICS

These materials are similar to the improved impact-resistant phenolics in properties and characteristics, but differ in addition preformability approaching that of the general-purpose materials.

Typical uses: heavy-duty housings and bases.

4. MEDIUM IMPACT RESISTANT PHENOLICS



These materials provide four to six times greater resistance to mechanical shock than the general-purpose phenolics. They cannot be preformed on automatic equipment, but can be preformed by hand.

Typical uses: pulleys, machine tool handles, parts for oil-well drilling apparatus.

5. HIGH IMPACT-RESISTANT PHENOLICS

These materials provide eight to sixteen times greater resistance to mechanical shock than the general-purpose phenolics. They are preformable only by hand.

Typical uses: heavy-duty flashlight housings, instrument housings, industrial truck wheels.

6. HEAT-RESISTANT PHENOLICS

These materials were developed primarily for service at elevated temperatures ranging from 350 deg. F. to 500 deg. F. They are the most dimensionally stable of all the phenolics.

Typical uses: cooking utensil handles and knobs, toaster and waffle iron parts.

7. SHOCK- AND HEAT-RESISTANT PHENOLICS

These materials provide up to two and a half times the impact strength of the general-purpose phenolics, along with high heat resistance. Parts molded from these materials will withstand exposure to temperatures up to 400 deg. F.

Typical uses: commutator insulation, railway equipment parts.

8. "LOW-LOSS" INSULATING PHENOLICS

These materials have outstanding electrical insulating properties, notably low power factor, high dielectric strength, and high volume resistivity, in addition to low water absorption and dimensional stability.

Typical uses: coil forms, tube bases, capacitor casings, ignition parts.

9. CHEMICAL-RESISTANT PHENOLICS

Materials in two groups, depending upon their varied formulations, have good resistance to water, acids, alkalies, alcohols, oils, greases, and other chemical products. Another desirable characteristic common to this group is minimum odor.

Typical uses: storage battery cups, sterilizers, milking equipment parts.

10. X-RAY SHIELDING PHENOLICS

These materials were developed primarily for x-ray equipment parts. A molded thickness of 5/16 in. is equivalent in shielding effect to 1 mm. thickness of lead.

Typical uses: x-ray equipment parts such as tube shields.

Additional detailed data is available on the various types and grades of BAKELITE Phenolic Molding Plastics. Write Department N-10, or call upon Bakelite technical representatives who are located in major industrial centers throughout the country.

Bakelite Phenolic Plastics

BAKELITE DIVISION

BAKELITE DIVISION, *Union Carbide and Carbon Corporation*, 30 East 42nd Street, New York 17, N. Y.

Need Thin Gage Bimetal?

Have you a thermostat metal problem requiring exceptional thin gage metal? General Plate can provide the solution with *Truflex* bimetal in thicknesses down to .0005" or ¼ the thickness of a human hair. And even in this unusual thinness, every succeeding order comes to you an exact duplicate of the original . . . uniform in tolerances, temperature reaction and performance.

General Plate thin gage Truflex Thermostat metal applications include instruments, thermometers and electronic equipment . . . as quick-acting thermostats where space and mass is at a premium . . . as thermal compensating coils or springs in thinner than "hairspring" dimensions.

General Plate manufactures Truflex Thermostat metal in a complete line of combinations to meet practically all requirements. It is available in strip, coils, sheets, ranging in widths from .020" to 8" . . . or in fabricated parts ready for installation into your products. Write for information and engineering assistance.

GENERAL PLATE

Division of Metals and Controls Corporation

104 FOREST ST., ATTLEBORO, MASS.

OTHER GENERAL PLATE PRODUCTS INCLUDE

Precious to base metal laminations
Base metal laminations
Alcuplate (copper or aluminum)
Silver solders
Laminated contacts, buttons, rivets
Platinum-fabrication-refinery
Age-hardening Manganese Alloy 720

50 Church St., New York, N. Y. • 4326 N. Elston Ave., Chicago, Ill. • 757 W. Third St., Mansfield, Ohio • Detroit, Mich. • Los Angeles, Calif.

Eaton Permanent Mold Gray Iron Castings

for
HIGH PRESSURE
CONTROL
MECHANISMS

- Free machinability
- Dense, homogeneous structure
- Freedom from leakage under pressure
- Machines to high, mirror-like finish
- Properly annealed; no growth or distortion after machining

Send for your copy of the illustrated booklet, "A Quick Picture of the Eaton Permanent Mold Process for Producing Gray Iron Castings."

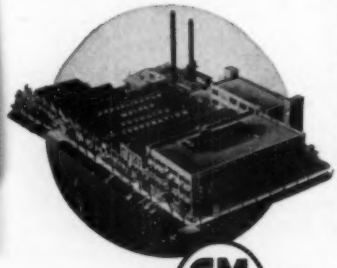
EATON MANUFACTURING COMPANY
CLEVELAND, OHIO
FOUNDRY DIVISION: 9771 FRENCH ROAD • DETROIT 33, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves * Tappets * Hydraulic Valve Lifters * Valve Seat Inserts * Jet Engine Parts * Rotor Pumps * Motor Truck Axles * Permanent Mold Gray Iron Castings * Heater-Defroster Units * Snap Rings Springtites * Spring Washers * Cold Drawn Steel * Stampings * Leaf and Coil Springs * Dynamatic Drives, Brakes, Dynamometers

*One of a Series of Messages to the Buyer of Custom Molded Plastics

"S.Q.C."...

this Consolidated *tool* makes your plastics parts live-up to their specifications!



Statistical Quality Control—referred to as one of "the sharpest management tools developed in half a century"—is in full operation here, at Consolidated. With it, we bring to our production quality an ability to make the molded part . . . and its counter*parts* conform to the specifications set down for it by the product manufacturer. The method, by far, represents today's most economical control. It eliminates double inspection—reduces rejects—and raises the standards of an entire output.

The system, one of scientific sampling, is documented by regular timings, gauge readings, jig constructions, graph plottings. In the hands of Consolidated's skilled plastics technicians, "S.Q.C." can't help but insure you the kind of plastics production that makes for a strong custom-molding relationship.

Whenever you are projecting a part—to be molded of plastic—and one that must toe the specifications line—call in a Consolidated sales engineer. Any one of our quickly reached offices is ready to apply experience, know-how and savings to your custom plastics problem.

(Please address Dept. J-4)

CMP

This is Consolidated . . . A Million Dollars in Custom Molding Facilities to Guarantee "Your Blueprint in Plastic" . . . with Savings!

Consolidated ***Molded Products Corporation***

Plant & Executive Offices: **309 CHERRY ST., SCRANTON 2, PA.**

Branch Offices and Representatives in **New York, Chicago, Milwaukee, Detroit, Cleveland, Bridgeport, Philadelphia—*and other principal cities***

Dependable Action

Positive Protection

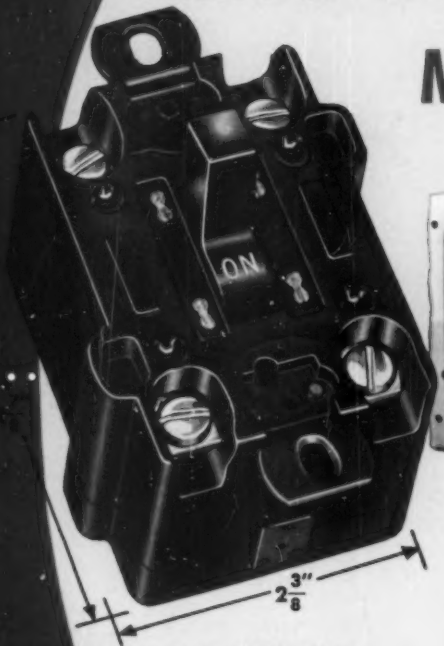
with

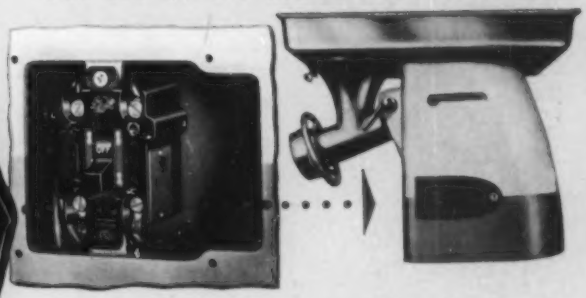
ARROW-HART

LOAD-LIMIT

MANUAL STARTERS

For AC or DC MOTOR CONTROL





IN THIS INSTANCE

TOLEDO SCALES USES A-H "LOAD-LIMIT" STARTERS FOR:

SMALL SIZE: 2 3/16" x 2 7/8" x 2 1/8"

FLUSH MOUNTING: *Compact. No projecting parts.*

...TY WIRING: *Plenty of room for quick, easy hook-up.*

...TE PROTECTION: *Both operator and ...hine protected against overload.*

THOUSANDS IN CONSTANT DAILY USE!

Yes, over 100,000 Arrow-Hart "LOAD-LIMIT" Starters have been sold to satisfied customers who keep coming back for more. Why? Because these starters are suitable for both AC or DC applications — are easy to install and maintain. The full range of interchangeable heaters, the trip-free operating lever and dependable make-and-break save time and money usually lost through shut-downs. Because flexibility and rugged construction are built into these starters, you can control 2 motors from 1 point-of-control — with minimum installation time and maximum economy of wiring and maintenance. Wall box mounting and plate screw spacings are standard.

The A-H "LOAD-LIMIT" Manual Starter is made in types to suit many application requirements — in 2-, 3- and 4-pole models, in ranges to give thermal overload protection to motors rated up to 5 H. P., single and polyphase through 440 Volts AC and 2 H. P., 230 Volts DC.

WRITE TODAY FOR LITERATURE

CONTROLS and APPARATUS FOR *Outstanding* PERFORMANCE

ARROW AH HART

ARROW·HART

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 HAWTHORN ST., HARTFORD 6, CONN., U. S. A.

ORIGINAL

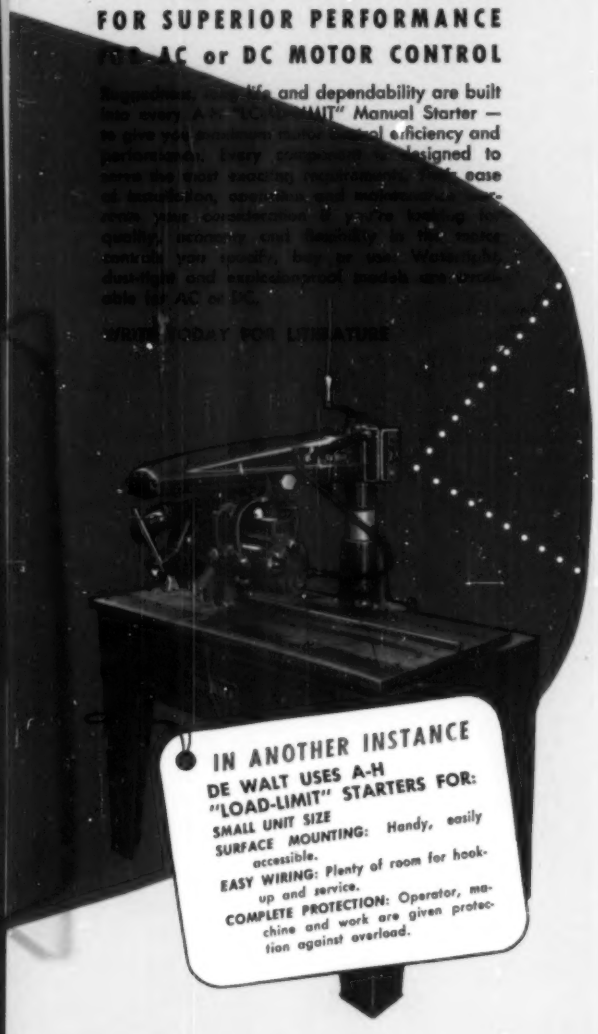
LOAD-LIMIT

MANUAL STARTERS

WITH THERMAL OVERLOAD PROTECTION FOR SUPERIOR PERFORMANCE FOR AC or DC MOTOR CONTROL

Ruggedness, long life and dependability are built into every A-H "LOAD-LIMIT" Manual Starter — to give you maximum safety, control efficiency and performance. Every component is designed to serve the most exacting requirements for ease of installation, operation and maintenance. Let us serve your consideration if you're looking for quality, economy and flexibility in the motor controls you specify, buy or use. Watertight, dust-tight and explosion-proof models are available for AC or DC.

WRITE TODAY FOR LITERATURE



IN ANOTHER INSTANCE

DE WALT USES A-H "LOAD-LIMIT" STARTERS FOR:

SMALL UNIT SIZE

SURFACE MOUNTING: Handy, easily accessible.

EASY WIRING: Plenty of room for hook-up and service.

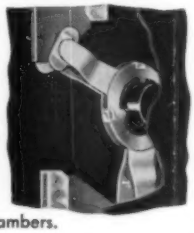
COMPLETE PROTECTION: Operator, machine and work are given protection against overload.

EASY TO WIRE . . TO SERVICE

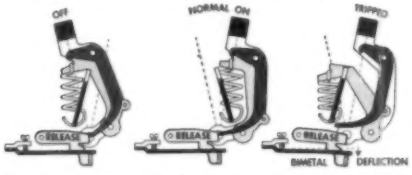
There's plenty of room in the unit for quick, easy wiring and maintenance. Large terminal screws and snap-on back save time in installation and servicing.

DEPENDABLE ACTION

Full-floating, self-aligning movable contacts are laminated for smooth, positive action and spring-clip contact pressure. Molded hub is fully insulated; casing is high impact Bakelite with individual arc-damping chambers.



POSITIVE PROTECTION



Here's positive overload response! Overcenter positive trigger and latch gives dependable tripping. Pushing lever to OFF relatches for reset.

FLUSH MOUNTING

One case is used for all sizes of units. Spring - mounting screws permit flexible automatic adjustment to any front **A** or back-of-panel **B** thickness up to ½".

THE ARROW-HART & HEGEMAN ELECTRIC CO., 103 HAWTHORN ST., HARTFORD, CONN., U.S.A.

BRANCHES IN:

BOSTON, CHICAGO, CLEVELAND, CINCINNATI, DALLAS, DENVER, DETROIT, LOS ANGELES, NEW YORK, PHILADELPHIA, SAN FRANCISCO, SYRACUSE

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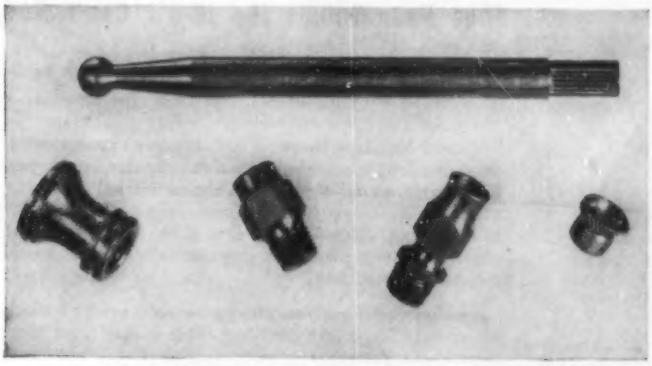
ARROW AH HART

Buy with Confidence
Profit by Performance

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by BRIDGEPORT BRASS COMPANY "Bridgeport" Headquarters for BRASS, BRONZE and COPPER



Screw machine items illustrating knurling and roll threading operations. Courtesy, Seymour Brass Turnings Company.

Free Machining Brass Rod Suitable For Roll Threading

Roll threading and knurling in the primary screw machine operation have done much to reduce the cost on thousands of precision and ornamental parts.

To keep pace with this trend, it has been necessary for the brass fabricator to carefully control temper to give free machining rod sufficient ductility to permit cold deformation of this type and at the same time maintain the highest machinability rating.

Bridgeport's Ledrite 6, free turning brass rod, was used for the parts shown in the accompanying photograph. These parts were made by Seymour Brass Turnings Company, Seymour, Conn., and are good examples of straight, diamond and bead knurling as well as thread rolling.

Stop Supports Long Piece

The long part at the top is an automobile mirror swivel arm. It is five inches long and ⅜" in diameter. The stock is fed out in a #2 Brown & Sharpe about 1", box turned, straight knurled and drilled from the turret. It is fed out again to a turret stop which takes the knurled diameter and rests against the turned shoulder to give support for the ball forming operation and cutoff. The work is turned at around 350 feet per minute and the feed is 0.0015" per revolution.

The two air-vent valves for heating systems are made from hex rod. Besides deep drilling and multiple forming, the threads are rolled in the screw machine and are ⅜" pipe. No difficulty is encountered in using the free machining Ledrite 6 Brass rod. The cord bushing has a diamond knurl and the threads are rolled. The knurl on the lamp finial has a ball knurl which is produced by actual deformation under pressure of the knurling tool. A narrow ridge is turned by the forming tool on the large end for knurling. The material shows no signs of cracking or splitting.

Temper Controlled

In sizes from ⅜" up, the temper of this rod stock is kept low enough to permit knurling and maintain free machining of its properties. If there is no knurling or roll threading involved, Bridgeport can supply rod in a higher temper. Screw machine fabricators, however, report little or no difference in the machining characteristics of the two rods despite the difference in temper.

In rod sizes below ⅜", Bridgeport rod is slightly harder in temper to insure against bending and buckling during machining. When using sizes below ⅜" if any difficulty is encountered in roll threading or knurling, it may be necessary to change to a softer temper or switch to another alloy which is more ductile such as Ledrite 2, which contains slightly less lead with the copper increased correspondingly. This alloy is also useful where exceptionally accurate knurls and rolled threads are demanded as in the precision instrument field. But for the majority of cases the standard free cutting brass rod is very satisfactory.

When selecting alloys, especially where intricate forming, roll threading or knurling is involved, Bridgeport's Laboratory should be consulted. Also make use of its valuable experience to help you solve other metal problems such as improving products or reducing costs.

BRASS · BRONZE · COPPER · DURONZE — STRIP · ROD · WIRE · TUBING

MILLS IN
BRIDGEPORT, CONNECTICUT
INDIANAPOLIS, INDIANA
In Canada:
Noranda Copper and Brass Limited, Montreal

BRIDGEPORT BRASS COMPANY
BRIDGEPORT 2, CONNECTICUT
Established 1865
"Bridgeport" *District Offices and Warehouses in Principal Cities*

Here is a *NEW* Carpenter Chrome-Nickel STAINLESS STEEL

that Does Things the 18-8's Can't Do!

Its *slow rate of work-hardening* solves fabricating problems frequently encountered with 18-8 type Stainless—

This new Stainless, invented in Carpenter's laboratories, work-hardens much *slower* than the regular 18-8 types. *Carpenter Stainless No. 10* is a Chrome-Nickel austenitic Stainless, ideal for cold headed fastenings such as recessed head screws. Also for the first time, Chrome-Nickel nuts have been produced commercially on automatic nut-making machines.

Carpenter Stainless No. 10 can be cold worked much easier than Type 302 Stainless. This makes it an ideal selection for parts that require severe coining or extrusion.

The corrosion resistance of Carpenter Stainless No. 10 is equal to or slightly better than that of the 18-8 types. It resists nitric acid well, sulphuric acid moderately.

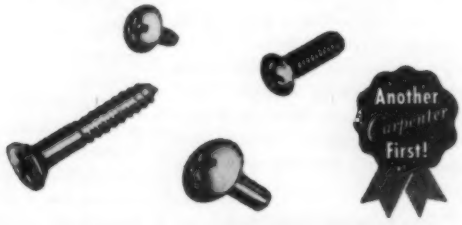
Forms commercially available include: wire and wire rods, cold drawn and ground bars, hot rolled bars and forgings, and forging billets.

Engineering Data Sheets are Now Available

These Carpenter Stainless No. 10 data sheets contain information on tensile properties after cold working, corrosion resistance, thermal expansion and electrical characteristics, etc. For your No. 10 data sheets, drop us a note on your company letterhead.

THE CARPENTER STEEL COMPANY
117 W. Bern Street, Reading, Pa.

Export Department: 233 Broadway, New York 7, N. Y. "CARSTEELCO"



Carpenter

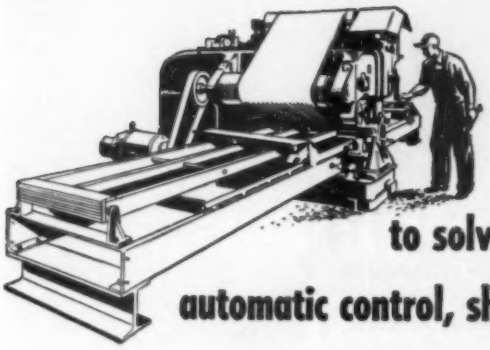
more than corrosion resistance

STAINLESS NO. 10

(Patent Pending)

FOR COLD HEADED AND UPSET PARTS

Type Analysis: Carbon . . . 0.08% max. Chromium . . . 16.00% Nickel . . . 18.00%



Smart design engineers use WARNER ICB UNITS to solve problems of clutching, braking, automatic control, shock and torque on their products

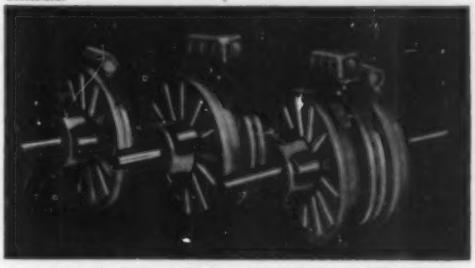
●IF YOUR PROBLEM

is to design your machine or its activating parts so that *you get:* (1) Push-button actuation at the machine or a remote control panel. (2) Fully or semi-automatic operation in "stop" or "start" of machine cycles. (3) Controlled acceleration or deceleration. (4) Automatic or manual adjustment of torque to load . . . or if your problem is *to eliminate:* (1) "Shock" from stop or start on gear trains and shafts. (2) Complex mechanical lever linkage, or air and hydraulic piping systems. (3) Vibration and hammering from solenoid operated brakes and clutches . . . or if you want to *increase production* from your machine by increasing the speed and number of cycle operations —

A WARNER ICB 9" x 2½" Brake Unit installed and housed on a standard 40 hp motor for a flat belt sander. Installation speeded up machine cycling, gave better, faster operational control. Installation is simple, compact and readily accessible.

●A GOOD SOLUTION

to any one or combination of these problems is WARNER ICB Units. WARNER ICB Units are electrically controlled and operated clutches and brakes. They are compact, mechanically simple and may be applied to machine spindles, drive shafts, or direct to electric motors. Because of their design, they may be operated individually or in combination, manually or automatically, by direct or remote control. They provide for infinite controlled variation of torque in either clutching or braking action within their rated capacities. Their action is smooth and shockless—fast and practically noiseless. They are self-adjusting and self-compensating for life. Their design guarantees a high rate of heat dissipation.

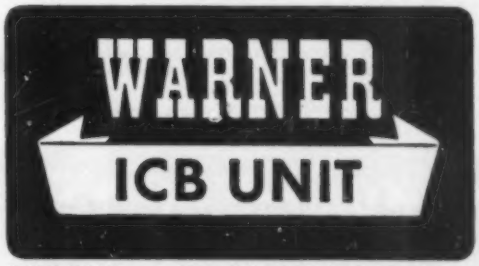


From left to right: a Warner ICB Brake Unit, a Warner ICB Clutch Unit, and a combination Warner ICB Clutch and Brake Unit. Note clean, smooth, compact, appearance — simple mechanical parts.

●MORE INFORMATION

on WARNER ICB Units and their application as clutches or brakes to various kinds of machinery is available. They may be used on continuous or intermittently operated machines. There is a complete range of sizes to meet both braking and clutching torque needs. If you have a design problem such as indicated above, write today for our free bulletin No. 701. If possible, state your problem. Not only will you receive your bulletin copy, but experienced WARNER ICB engineers will be glad to consult with you without obligation. Write direct to WARNER ELECTRIC BRAKE MANUFACTURING COMPANY, Beloit, Wis.

Bulletin 701 contains complete specifications and description of WARNER ICB Units. See for yourself how they offer advantages never before available on industrial clutches and brakes. Write for it today — no charge.



WARNER ICB Units are manufactured by Warner Electric Brake Mfg. Co. — pioneers in the field of electric brake design and application since 1927.

Kidde latch costs CUT IN HALF by Powder Metal

When the trigger latch of the new Kidde fire extinguisher valve was designed for powder metal, substantial production savings were realized . . . a stamping of the same piece would cost twice as much . . . a forging three times as much . . . a precision casting six times as much.

The latch is of brass powder, cadmium plated . . . and meets the Kidde specifications of corrosion resistance and tolerances of plus 0.002" and minus 0.008". Machining is entirely eliminated.

The trigger latch is one of hundreds of products now being made successfully and profitably by powder metal processing. Possibly various mechanical parts you use or make are adapted for powder metallurgy production.

The new brochure "Powder Metallurgy Today" tells all about powder metallurgy and what this profitable production process can do for many manufacturers. Write for your copy, today. Stokes makes no parts — only the presses on which parts are made—but offers a free analysis and report on the adaptability of your mechanical parts for powder metal production. No obligation, of course.

F. J. STOKES MACHINE COMPANY

F. J. Stokes Machine Co.
5600 Tabor Road
Philadelphia 20, Pa.

☐ *Without obligation, send me "POWDER METALLURGY TODAY".*
☐ *Part or blueprint is attached for free analysis.*

Name _____ Title _____

Company _____

Address _____

City _____ Zone _____ State _____ GR

take a simple thing like a casting

Its per-pound cost from the foundry is one thing. Its *final* cost, machined, handled, assembled into place and painted as part of your finished product, may be quite another.

An aluminum or magnesium casting from Alcoa may cost you a little more than one of another metal—as it comes from the foundry. But what machining is needed, can be done much faster. It usually can be handled by hand instead of hoist. Assembly goes much faster. And painting often can be eliminated.

These same economies are characteristic of most Alcoa semifinished products. The net result is—from the designer's standpoint—the kind of product he's always dreamed about—in performance, in production, in sales. And usually at no higher cost than the old way.

IN ADDITION TO FLAT AND COILED SHEET • ALCOA MAKES INGOT • BAR ROLLED AND EXTRUDED SHAPES • WIRE • ROD • TUBING • PIPE • SAND DIE AND PERMANENT-MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS ELECTRICAL CONDUCTOR • SCREW MACHINE PRODUCTS • FASTENERS • FOIL FABRICATED PRODUCTS • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

ALCOA

ALCOA FIRST IN ALUMINUM

In the following pages, Alcoa presents facts for sales designers on representative Alcoa products. On the last page of the Alcoa section will be found the Alcoa offices through which information on aluminum is available. Aluminum Company of America, Gulf Building, Pittsburgh 19, Pennsylvania.

THE ALCOA PRODUCTS ADVERTISED HERE ARE BACKED BY THE BASIC ENGINEERING LITERATURE OF THE INDUSTRY...

YOU CAN DO

Alcoa Extrusions make tough shapes easy

Many's the odd-shaped part that suddenly became very simple and very cheap–when a designer thought of it as an Alcoa Aluminum Extrusion.

This endlessly versatile process lets you design *exactly* the shape you need, and does away with many of the design compromises required when parts must be built up by welding or riveting.

To help you express your design in an aluminum extruded shape, Alcoa will work with you from the drawing board stage to the finished extrusions.

and often give you major savings

The use of Alcoa Aluminum Extrusions frequently permits one part to do the work of several, do it better, and with notable savings in fabrication and assembly operations. Dies often pay for themselves on the first thousand pieces.

as well as a sounder finished product

The strength of Alcoa Aluminum and its alloys, their light weight and corrosion resistance may make an important contribution to the soundness of your end product. So may the clean-lined sections which extrusion produces. The accumulated research and production experience of Alcoa is available to tailor these properties to your particular needs.

DESIGN PROBLEM?

"ALCOA ALUMINUM EXTRUDED SHAPES" is an informative booklet which shows you the design potentials of this endlessly versatile process.

Fill out the coupon at right. We will send you the booklet plus a paperweight made of an Alcoa Aluminum Extrusion.

Send for this free booklet today!

Aluminum Company of America
2155D Gulf Building, Pittsburgh 19, Pa.

Please send a free copy of "ALCOA ALUMINUM EXTRUDED SHAPES" and a paperweight to:

Name_____

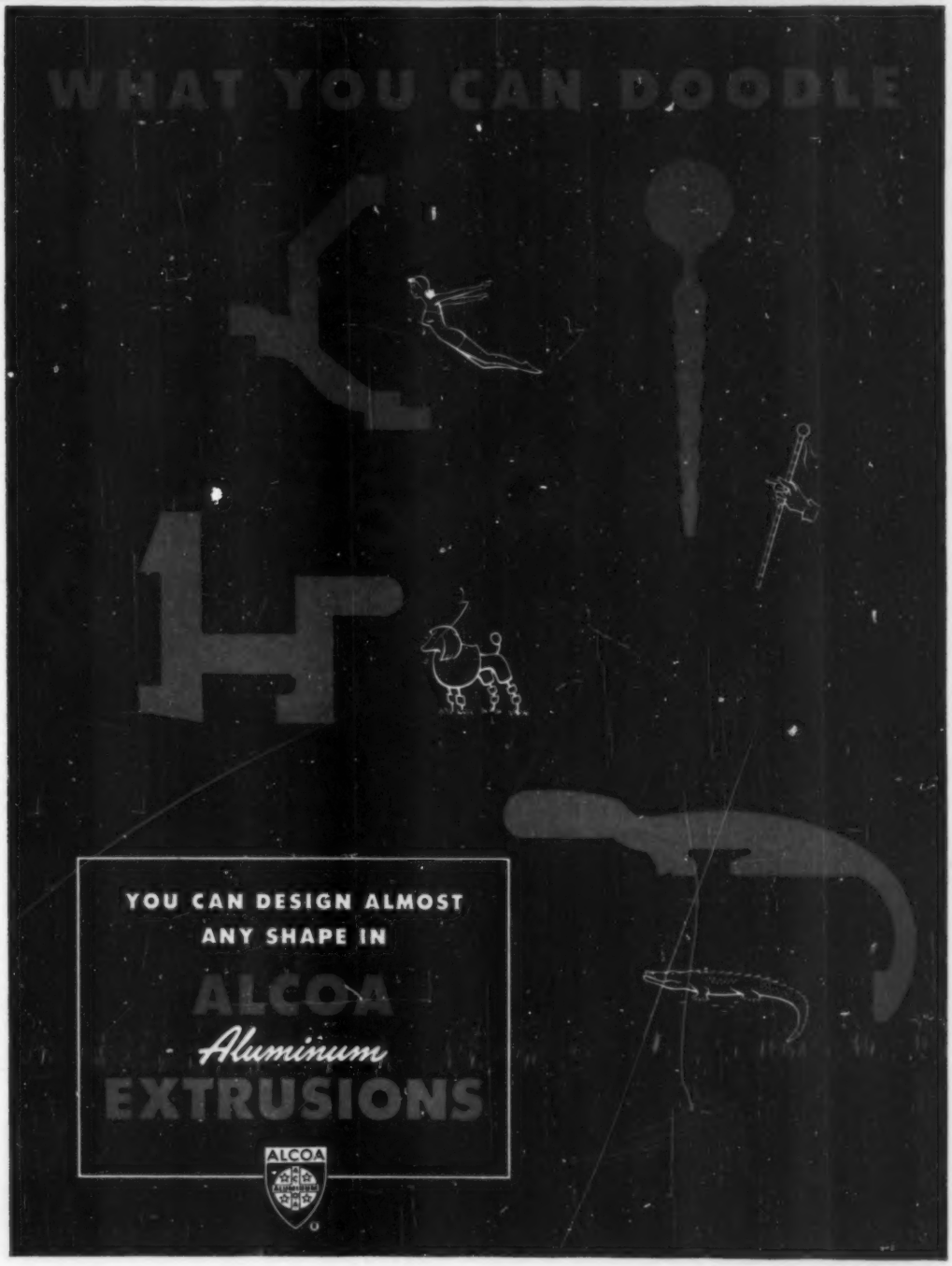
Title_____

Company_____

Street Address_____

City_____ Zone____ State_____

IN ADAPTING THEM TO YOUR USE, YOU ARE INVITED TO MAKE FULL USE OF ALCOA'S OUTSTANDING ENGINEERING HELP



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Surprise yourself today by figuring one of your screw machine jobs two ways: In brass. In Alcoa Aluminum. You get three times as many parts per pound with aluminum.

Figure machining costs about equal for aluminum ... sometimes less. As you know, aluminum needs no costly plating or painting to stay clean and bright. But if a finish is necessary, aluminum takes and holds them all.

Get complete data from the free book, "Alcoa Aluminum in Automatic Screw Machines." Write ALUMINUM COMPANY OF AMERICA, 2117D Gulf Building, Pittsburgh 19, Pennsylvania.

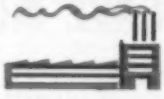
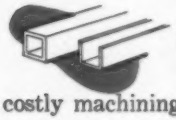
Like these

ALCOA *Aluminum* SCREW MACHINE STOCK

ALCOA ALUMINUM

THE ALCOA PRODUCTS ADVERTISED ON THESE PAGES ARE BACKED BY ALCOA'S RIGID QUALITY CONTROL . . .

No Dice

Squawks from his salesmen had this chair manufacturer bothered. These chairs have no sales appeal . . . they're too heavy! He wanted to make an all-magnesium model, but his shop manager said, "No dice we don't know how to handle magnesium". Not easily stalled, he contacted light-metal headquarters, Aluminum Company of America.  There he found that simple procedures make using magnesium easy*. Magnesium extrusions,  he learned, were a natural for his chair frames. They eliminate costly machining. So he decided to join the hundreds of manufacturers who whisk through a million pounds of magnesium every month. Now, made of American Magnesium Extrusions, his chairs are lighter . . . . his costs are lower. His salesmen are making competition take a back seat.

**No change in insurance rates.*

These two, free books on magnesium and our broad technical experience can help your products, too. Write Aluminum Company of America, sales agent for American Magnesium Products, 2109D Gulf Bldg., Pittsburgh 19, Pennsylvania.

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AMERICAN MAGNESIUM CORPORATION

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ALCOA PRODUCTS ARE PROVIDED FROM ALCOA PLANTS IN CONVENIENT SEMI-FABRICATED FORMS...

Fasten Aluminum with Aluminum and SAVE MONEY

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Save up to 56% on Wood Screws

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One of Alcoa's modern plants die casts these juicers by the thousands. Why? Because they produce sound, on-grade castings at exceptionally low prices.

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THESE ALCOA SALES OFFICES *Will Aid You*

These sources of the Alcoa products (described on the preceding pages) are as near as your telephone. Let them serve you with engineering help, literature, and a pound or a ton of the Alcoa product that best meets your needs.

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CALIFORNIA
Los Angeles—108 West 6th Street
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San Francisco—615 Russ Bldg.
Phone Yukon 6-6484

COLORADO
Denver—524 U. S. National Bank Bldg.
Phone Tabor 4638

CONNECTICUT
Fairfield—1333 Post Road
Phone Fairfield 9-5221
Hartford—Capital Bldg., 410 Asylum St.
Phone Hartford 5-2192 to 5-2196

DELAWARE
Wilmington—Delaware Trust Bldg.
Phone Wilmington 8-4138 and 8-4139

FLORIDA
Tampa—1004 Tampa Theatre Bldg.
Phone 2-1984
Miami—1129 Alfred I. Du Pont Bldg.
Phone Miami 9-0651

GEORGIA
Atlanta—1800 Rhodes-Haverty Bldg.
Phone Cypress 4681-2-3-4-5

ILLINOIS
Chicago—520 N. Michigan Ave.
Phone Delaware 7-8181
Peoria—415 Commercial Natl. Bank Bldg.
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INDIANA
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Davenport—503 Kahl Bldg.
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KANSAS
Wichita—411 Fourth Natl. Bank Bldg.
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Louisville—1154 Starks Bldg.
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LOUISIANA
New Orleans—627 Whitney Bank Bldg.
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Springfield—507 Torbell—Watters Bldg.
Phone Springfield 3-5103

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Detroit—610 New Center Bldg.
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Minneapolis—1060 Northwestern Bank Bldg., Phone Atlantic 3528

MISSOURI
Kansas City—2300 Power & Light Bldg.
Phone Victor 3870
St. Louis—10th Floor, Continental Bldg.
Phone Franklin 6700

NEW JERSEY
Newark—744 Broad Street
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NEW YORK
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Phone 4-0146, 4-0147, 6-7489
Buffalo—1880 Elmwood Avenue
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Phone Murray Hill 6-8046 to 6-8058
Rochester—1331 Lincoln Alliance Bank Bldg., Phone Baker 2630
Syracuse—408 State Tower Bldg.
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OHIO
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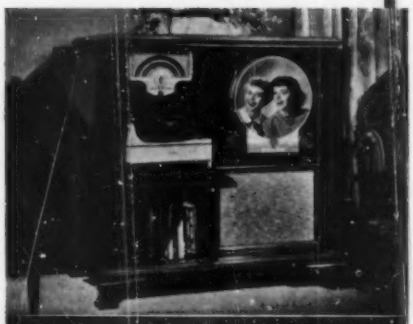
ECONOMY!

. . . ONE-PIECE CONSTRUCTION CUTS PRODUCTION COST, SIMPLIFIES ASSEMBLY AND IMPROVES APPEARANCE

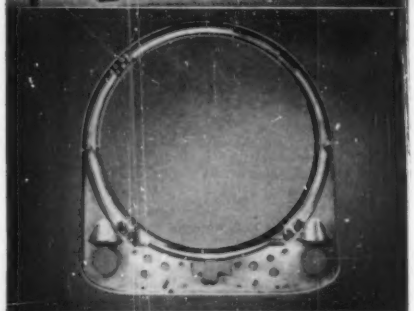
CUTS PRODUCTION COST →

By any method of production other than die casting, the combination screen bezel and control panel on this new Zenith television receiver would be an assembly of several parts—instead of a single ZINC Die Casting! Furthermore, as a die casting, there is no scrap loss.



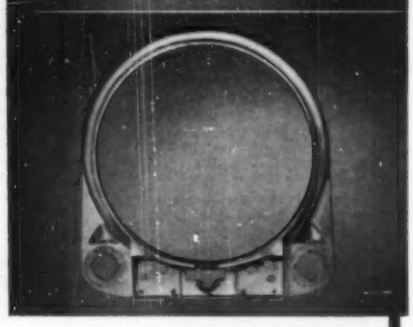
SIMPLIFIES ASSEMBLY →

This rear view of the bezel-panel casting reveals the various cored openings and integral fastening elements which simplify assembly. The openings are accurately positioned and thus assure easy lining up of the controls. The rigidity of the ZINC die casting also aids assembly. When the casting is drawn against the picture tube, the rigid bezel places the tube in the correct plane with the bezel opening.



IMPROVES APPEARANCE →

The smooth as-cast surfaces of this part—at the focal point of the television receiver—are easily finished in a combination of plating and paint. The raised ring on the bezel (see front view here) is brass plated. The balance of the bezel receives a tinted lacquer and the control panel an enamel finish.

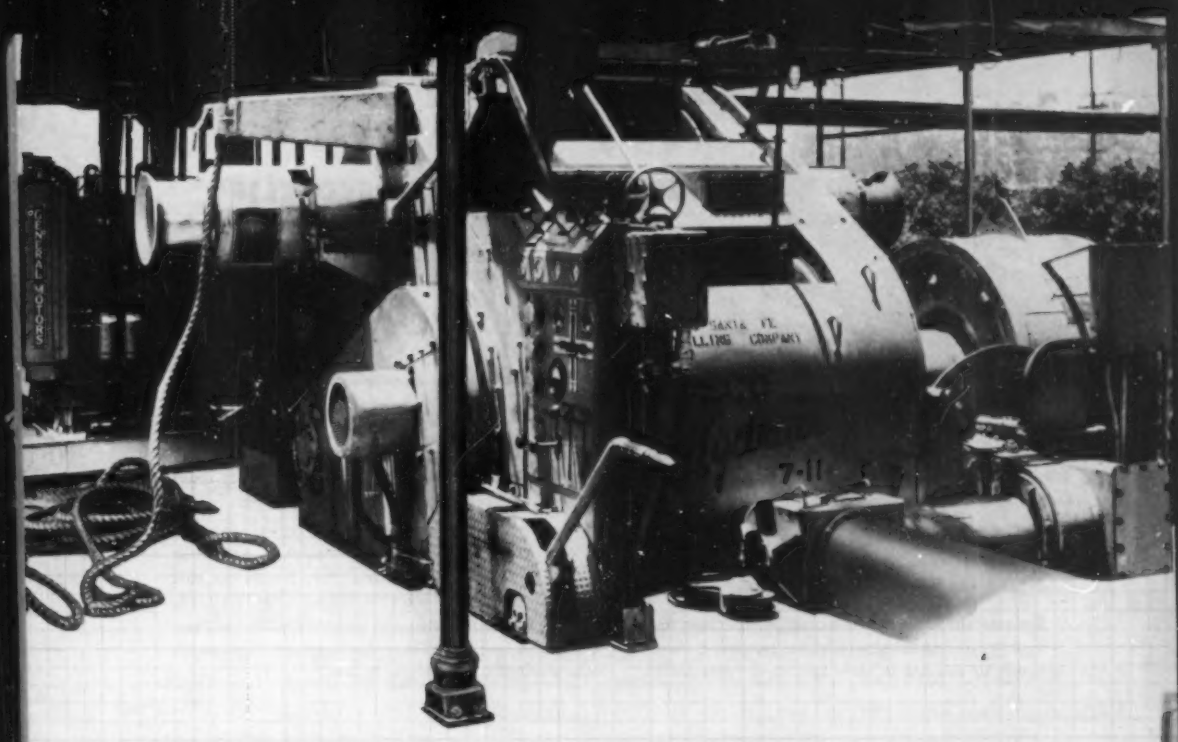


There are many other ways in which ZINC die castings can lower production costs without sacrifice of quality. These are the reasons why ZINC die castings are the most widely used. Every die casting company is equipped to make ZINC die castings and will be glad to discuss their advantages with you—or write to us.

The New Jersey Zinc Company, 160 Front Street, New York 7, New York.

ZINC
FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on
HORSE HEAD SPECIAL (99.99+% Uniform Quality) ZINC



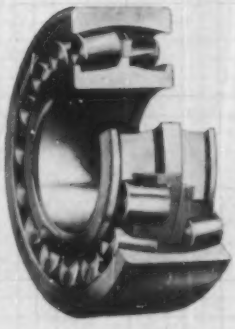
backing up a 25-ton line pull

TORRINGTON SPHERICAL ROLLER BEARINGS

In IDECO's Hydrair 7-11 Rig, heavy loads on compound, transmission, drum and cathead shafts are handled smoothly and efficiently by Torrington Spherical Roller Bearings.

The large area of roller-to-race contact is uniformly maintained and shafts turn freely even when momentary overloads cause deflection.

These features of heavy-duty Torrington Spherical Roller Bearings assure long service life with minimum maintenance. Our engineers will welcome an opportunity to help you secure these advantages for your product.



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TORRINGTON *SPHERICAL ROLLER* **BEARINGS**

SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • NEEDLE • BALL • NEEDLE ROLLERS

SPEED NUTS® and SPEED CLIPS®

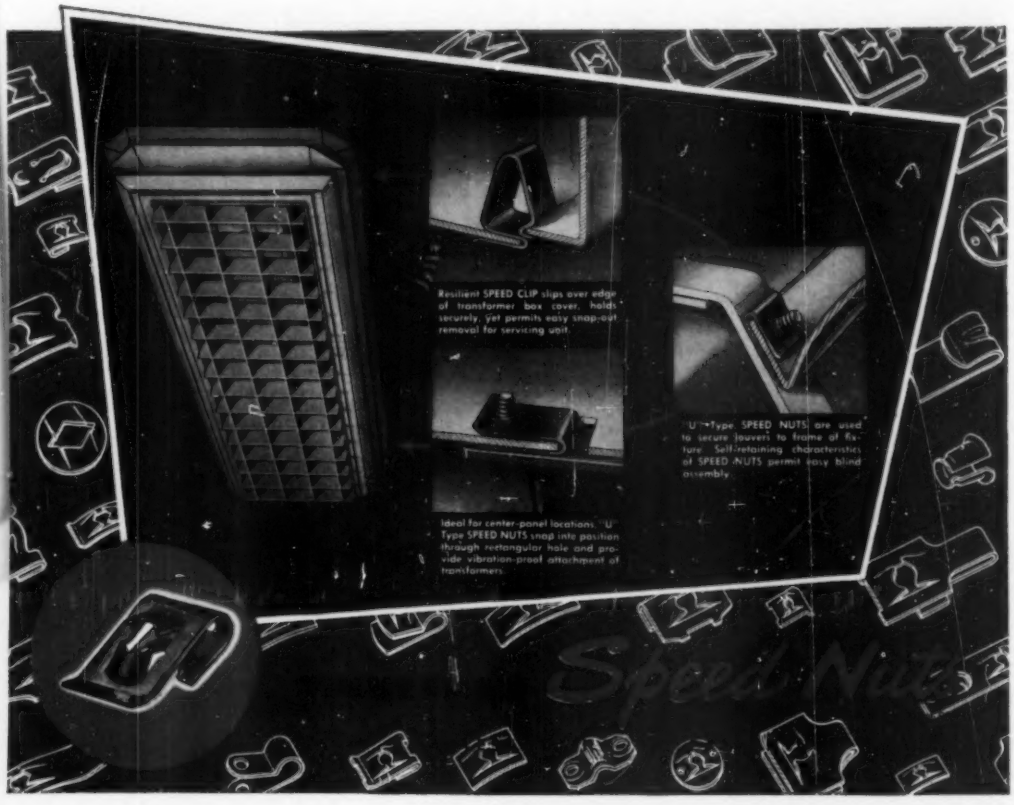
"Shed New Light"

ON LIGHTING FIXTURE ASSEMBLY COST

Here's how Tinnerman fasteners "lightened" cost burdens three ways for Joleco Corp., St. Louis manufacturers of fluorescent lighting fixtures.

1. A substantial assembly savings of $1.79 per unit was effected by switching to SPEED NUTS and SPEED CLIPS.
2. Because they are self-retaining, Tinnerman fasteners eliminated the need for investing thousands of dollars in new fastening machinery.
3. Rejects were greatly reduced, because SPEED NUT brand fasteners minimize assembly damage and compensate for misalignment.

See *your* assembly costs in a new light—through a comprehensive Fastening Analysis. Ask your SPEED NUT representative for details on this service. Or write: TINNERMAN PRODUCTS, INC., Cleveland, Ohio. In Canada: Dominion Fasteners Limited, Hamilton. In England: Simmonds Aerocessories, Treforest, Wales.


Resilient SPEED CLIP slips over edge of transformer box cover, holds it securely, yet permits easy snap-out removal for servicing unit.
"U"-Type SPEED NUTS are used to secure louvers to frame of fixture. Self-retaining characteristics of SPEED NUTS permit easy blind assembly.
Ideal for center-panel locations, "U"-Type SPEED NUTS snap into position through rectangular hole and provide vibration-proof attachment of transformers.
Speed Nuts

The Power of the Payroll

THERE IS NO MARKET for modern production machinery in China. An army of coolies working for a few cents a day carrying baskets of dirt is cheaper than the cost of owning and operating power shovels and materials handling equipment. Nor can the coolies buy home appliances. Which illustrates the fact that high wage rates are the greatest single force that impels and compels the development of better production machinery and more economical product designs.

Wages are the most significant element that makes profitable the developing of better production machinery. As long as the wage rates do not go up faster than the offsetting economies created by the use of better tools and lower cost designs everybody benefits. For design engineers there is a bright silver lining around the clouds created by strikes.

Developments over the past years in the railroad and coal mining industries strikingly demonstrate some of the results of high wages. Twenty years ago it required thirty men working one month to screen the ballast on one mile of railroad track. Today, less than ten men do the job in an hour and a half. More recently, the further introduction of automatic tie tampers and new equipment for track raising and cleaning between ties have further reduced labor costs and do the job better. In spite of the latest wage increases some railroads report that maintenance per mile of track costs less now than it did a year ago.

In the coal mining industry, new machines have cut man hours of labor per ton of coal considerably. Use of the latest machinery has cut the mining costs more than enough to offset the latest wage and royalty increases.

Many similar examples could be cited relating to the savings achieved through the use of improved metal working machinery. However, comparable overall figures would be extremely difficult to establish because the savings in the metal working industry relate to specific operations of which there are an untold quantity. But as we compare the man hours production today with that required a decade ago in the manufacture of automobiles, home appliances, and similar products, the gains are tremendous.

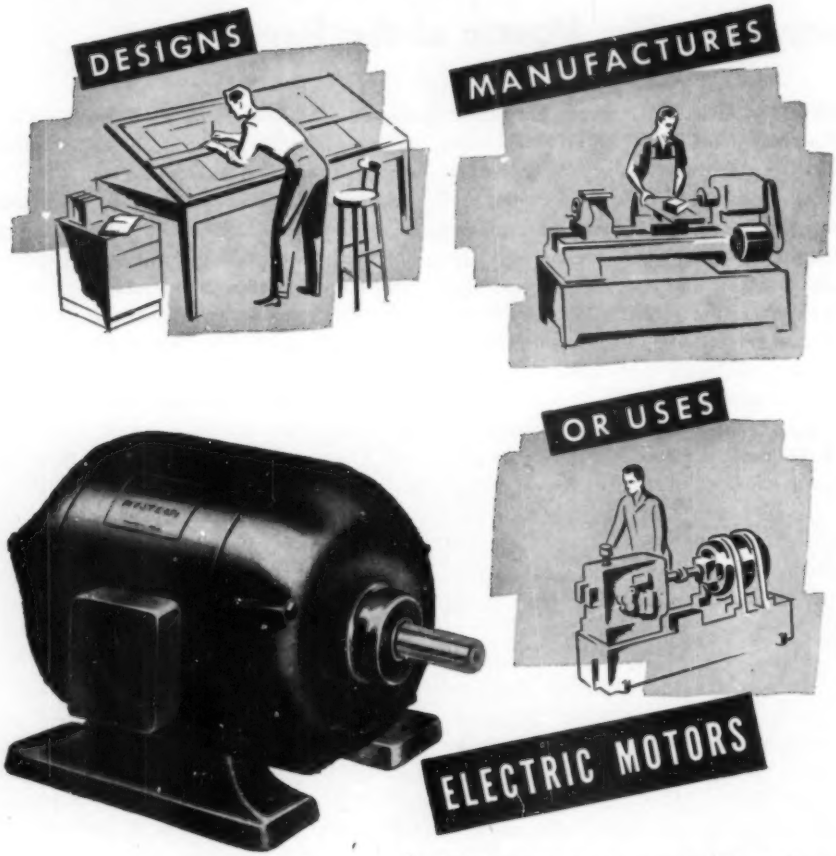
When all is said and done, standards of living can be raised primarily only by more efficient production machinery and more economical designs of manufactured products. Both are the creations of the design engineer. When wage rates are static, competition compels individual companies to seek design and production economies. When wage rates go up, a further impetus is created. Today, the latter is the situation.

Costs must be reduced without lowering wage rates or even in spite of higher wage rates. The two biggest factors to achieve that goal are designs that are inherently cheaper to manufacture and production machinery that produces more for less man-hours. There is much work to be done by the product engineers.

G. F. Rodenholt

HOW TO SAVE MONEY

IF YOU ARE A MAN WHO...



Nothing Rolls Like a Ball...

NEW DEPARTURE
BALL BEARINGS

NEW DEPARTURE
DIVISION OF GENERAL MOTORS
BRISTOL, CONNECTICUT

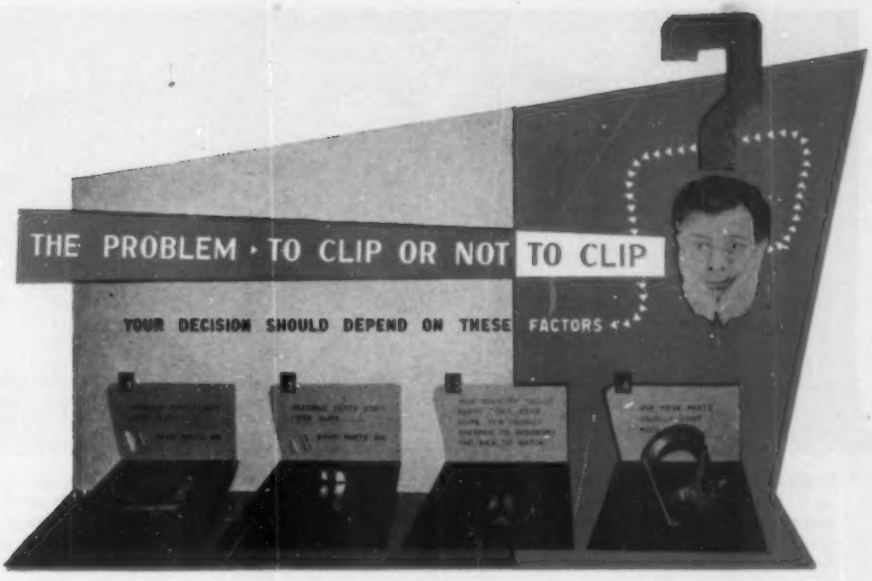
91

As almost everyone knows, many modern electric motors never need re-lubrication.

They run—an ever-increasing number of them—on New Departure self-enclosed ball bearings. For these are the bearings which (1) keep lubricant in, (2) keep dirt out, (3) reduce maintenance, and (4) simplify design.

These New Departure ball bearings save motor users money in several ways. They reduce lubrication costs to zero! They eliminate burnouts, costly repairs and lost time due to over or undergreasing. And they make motors last longer—as evidenced by numbers of installations that have been running for many years without attention.

Yes, you can save money by being certain the electric motors you design or manufacture or use are equipped with New Departure self-sealed ball bearings. Interesting booklet "Sealed" will be mailed on request.



Engineering Displays

TRAIN DESIGNERS to automatically screen each part for any constructions or arrangements that have high production costs.

SUPPLY DATA on designs for specific production techniques and teach basic concepts which lead to economical fabrication.

STIMULATE COST-CUTTING programs in the engineering department and arouse enthusiasm for low-cost, efficient designs.

O. A. WHEELON
Production Design Engineer
Douglas Aircraft Company, Inc.

EVERY GOOD SHOP TAKES PRIDE in being able to make difficult parts. Thus, it is all too easy for a design engineer to release parts for production on the basis of a sample that took the best workman two days and three or four trys to make. This trouble arises from approaching the production problem with the question "Can this part be made?" rather than "Can this part be made economically, on inexpensive tooling, and with a low rejection rate?" The essence of developing cost-conscious engineers is to teach them to provide an affirmative answer to the latter question.

Two objectives must be accomplished: (1) The designer must become so cost-conscious that he screens each idea automatically, with an eye to economical production, in the sketch stage; (2) he must be provided with the basic design concepts that lead to low-cost fabrication, as well as the specific details of the production techniques.

In their search for a better way to highlight these objectives, the Production Design Group at Douglas Aircraft Company turned to engineering displays as one good method.

Each display consists of three elements:

1. The poster—dramatically presenting one major theme.

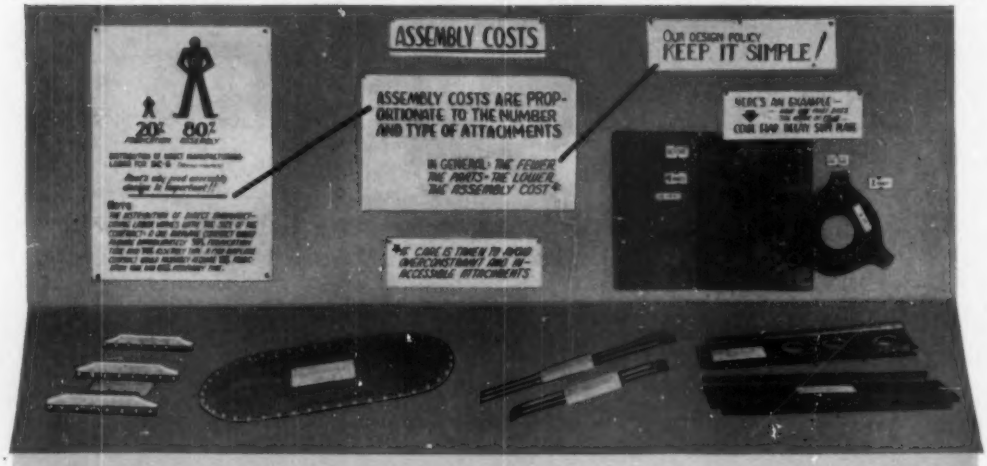
2. A collection of parts—showing actual examples of "right" and "wrong."

3. Data sheets—which discuss the major point and provide the data for the designer's notebook.

At Douglas, many displays were built around DC-6 parts. Each display showed some of the production

SO OUR OBVIOUS POLICY IS TO DESIGN FOR THE HYDRO PRESS WHENEVER POSSIBLE
HAND FORMING AND CAMEL DIES ARE EXPENSIVE
HERE'S AN EXAMPLE OF COST
8.21¢
3.23¢
2.47¢

DESIGN FOR THE HYDRO PRESS. Wherever sheet metal parts require severe deformation, it is axiomatic that expensive tooling or a great deal of hand work will result. Therefore, design policy is to plan on shallow-formed parts for hydro press (rubber pad press) forming, with a minimum of hand work. Since an airplane is largely made up of formed sheet metal, the simplification of the design for easy press forming is of utmost importance. Usually there is a good, economical design that will not exceed forming limits of the material.


ASSEMBLY COSTS
OUR DESIGN POLICY
KEEP IT SIMPLE!
20% FABRICATION
80% ASSEMBLY
ASSEMBLY COSTS ARE PROPORTIONATE TO THE NUMBER AND TYPE OF ATTACHMENTS
IN GENERAL: THE FEWER THE PARTS - THE LOWER THE ASSEMBLY COST
CARE IS TAKEN TO AVOID OVERCONSTRAINT AND INACCESSIBLE ATTACHMENTS

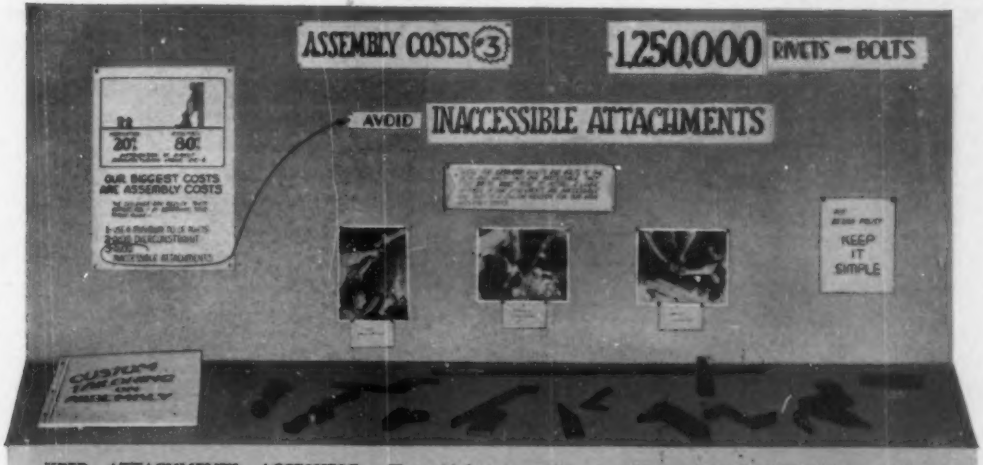
CONCENTRATE ON ASSEMBLY COSTS. Studies of the distribution of direct manufacturing labor costs have shown that fabrication cost amounts to about 20 percent, while assembly accounts for 80 percent. Obviously, design attention should be devoted to assembly, for it is there that the greatest savings are possible. A reduction in the number of pieces will save assembly time and overall cost if (1) the parts are not too difficult to make, (2) the design does not require a lot of hand fitting, (3) the designer has not introduced inaccessible attachments.

problems, and was planned to cover just one major point. The idea was to drive home, forcefully, one principle that would be valuable and effective for all the design groups.

A good location for these exhibits is particularly important. By locating the display on the center aisle of the design department, all engineering personnel pass it each time they enter or leave the department. Furthermore, manufacturing and tooling personnel cannot miss the display as they pass through to contact the engineers. Some displays have been loaned to other departments when the subject was of particular interest to them.

Usually, each exhibit is left on display 10 days to two weeks. A record is kept of the number of data sheet "handouts" taken each day from the display. In this way, the prevailing interest is known, and the supervisory personnel have some measure of how

AVOID OVERCONSTRAINT. Too often the designer creates an assembly that is inherently and unnecessarily expensive because he forgot to think of "overconstraint." Overconstraint occurs whenever relative motion between parts is prevented in more than one way, or closely related, where a part is required to fit at more points than is truly necessary. A little reflection will show many costly examples of designer's ignorance or neglect of this problem. Handwork, such as reforming and shimming, usually is evidence that overconstraint is present.



KEEP ATTACHMENTS ACCESSIBLE. The third important element of assembly costs lies in the inaccessibility of attachments. Studies on the DC-6 showed that inaccessible locations for fasteners ran up installation costs 50 to 200 percent over the installation costs in normally accessible spots. With 1,250,000 rivets and bolts in a single DC-6, the implications of such design are obvious. Minimum number of parts, minimum constraint, and accessible attachments are the foundation for low assembly costs in any kind of product.

well the information is getting across.

The scope and effectiveness of these engineering displays can best be appreciated by a study of some of the photographs, and the concepts they teach.

Exhibits have been developed to teach important design goals, which are not illustrated here for lack of space. For instance, one exhibit dealt with adapting existing parts. Herein lies the opportunity to step up quantity requirements, so that a given part is far more economical to produce. By adapting an existing part rather than designing a new one, the engineer saves development costs, engineering costs, and tooling costs, and usually obtains a better part, free from any possible unforeseen problems of a new design. Furthermore, the larger the quantity of the part to be used, the smaller the proportion of the cost tied up in engineering and tooling.

Designers also should be taught to

make the most of "carry-over." A factory and engineering department, or any production team, learns in the same way as does an individual—by experience. A sure way to reduce costs is to make use of the available engineering and production know-how. This exhibit showed how departures from established practice create new problems in engineering, tooling, procurement, fabrication and assembly. Learning curves or "progress curves" illustrated how significantly carry-over enters into design economy. Four rules are taught: (1) Use existing parts in assemblies wherever feasible; (2) Modify existing parts by simplification and elimination; (3) Use parts that can be made from existing tools; (4) Use designs that present no new manufacturing problem. In brief, stick to proven techniques.

Another exhibit deals with minimum tooling. Charts were developed to show how tooling money was spent on recent aircraft, and three fundamental principles were emphasized: (1) Design for less tooling, (2) design for cheaper tooling, (3) make sure expensive tooling is not obsoleted by design changes.

The importance of avoiding marginal fabrication was taught. The theme was that good design never pushes the material, dimensions, fabrication technique, or human skills to the limit. If the designer tries to work right up to the margin of capabilities of the men, materials or methods, he can anticipate that inherent variations are bound to result in scrap. A great deal of excessive scrap can be traced to designs that were too marginal.

Subjects such as designing for serviceability, favorable passenger reaction, producibility and similar topics also have been treated.

How to Make Engineering Displays

A glance at these illustrations may convince the reader of their effectiveness. To those who want to make use of engineering displays, this set of rules is offered.

Subject Matter: It should be of general interest.

The Poster: (1) It should have a theme sentence or a concise title: (2) it must make only one major point; (3) it must repeat the design policy in simple terms; (4) it must keep descriptive and explanatory material brief; (5) it should include photographs, sketches and graphs to tell the story; (6) it must attract and guide the eye by the arrangement of the material and by the application of color.

Display Table: (1) By all means, sample parts should be included to illustrate the theme (but don't overcrowd the table); (2) where possible, before-and-after treatment of parts should be used: (3) an interest pattern should be developed to guide the eye. Such tricks as coloring of parts, supplying a light box and negatives, or running ribbons from poster to parts are effective.

Data Sheets: (1) The text must be brief and to the point; (2) it should include some figures—that is, numbers in the form of charts, tabulations or sketches; (3) rules should be listed; (4) pages should be dated and numbered. Sufficient information should be given so the designer will keep it in his personal notebook rather than throw it in the "circular file" (wastebasket). Lithograph reproduction is recommended. And ample time should be allowed for printing, so that the pages are available with the display.

GOOD DETAIL DESIGN. Each production method has its own rules for achieving economical design, but whether it is sheet metal, forging, casting, or machined part, the same design check list applies.

1. Simplicity: Is the part as simple as practicable?
2. Function: Will a part perform its function?
3. Design Detail: Is it an efficient structure?
4. Weight: Has the correct design load been used?
5. Cost: Has optimum construction been used?
6. Overconstraint: Has it been avoided in assembly?

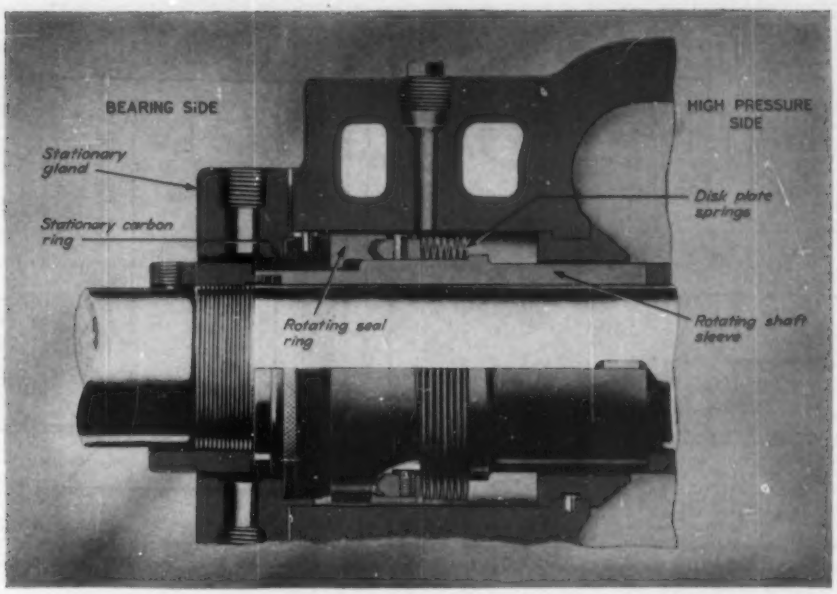


Fig. 1—Seal and stuffing box for a centrifugal pump. Plate springs bear against shoulder on shaft sleeve and locking collar. Seal is at contacting faces of the stationary carbon ring and the rotating seal ring.

MECHANICAL SEALS

Theory and Criteria for Their Design

Effects of surface tension, liquid back pressure, viscosity, spring force and face proportions on leakage through mechanical seals. Qualitative basic equations are derived for leakage through gaps and then analyzed to explain the performance of seals with non-volatile and volatile liquids.

A. BRKICH
Development Engineer, Ingersoll-Rand Company

ALTHOUGH THE APPLICATIONS of mechanical seals are numerous, little is known about their theory of operation. Many designs have been arrived at by a process of trial and error. When new applications arise, seals are usually designed by extrapolating information obtained from earlier experience. As long as the service is for cold lubricating liquids, this procedure may be satisfactory. But when unusual conditions are present, such as high pressures and temperatures with a volatile liquid, such procedure may lead to failure and further unsatisfactory design.

The mechanical parts of seals are designed in many ways. One design is shown in Fig. 1. In all designs, however, the objective is to maintain flexibly a close relation between one flat rotating face and a stationary flat face. The main problem is to proportion the faces and pressure areas in a manner such that leakage and wear will be a minimum. Theoretically, seals can be designed that have no wear and practically no leakage. This optimum condition requires perfectly flat faces and complete absence of vibration. Even though these conditions may be unattainable, the theory still has merit in that it can indicate trends.

LEAKAGE EQUATION. In developing a design theory for mechanical seals, the first step is to derive an equation for leakage through an axial gap. Since it is small, the flow can safely be assumed to be laminar, which simplifies the task. By equating the pressure force and the shearing forces acting on an incremental ring of fluid as shown in Fig. 2, Where

p = liquid pressure drop between r_3 and r_1, psi

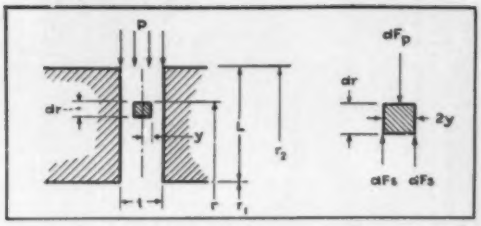


Fig. 2—Ring of fluid in an axial gap between two flat faces.

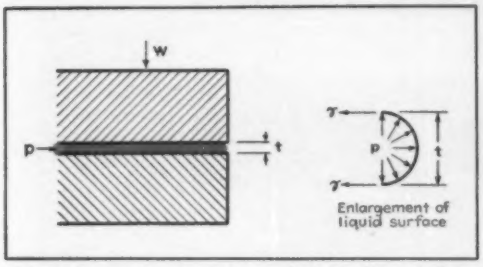


Fig. 3—Film between two stationary absolutely flat steel plates.

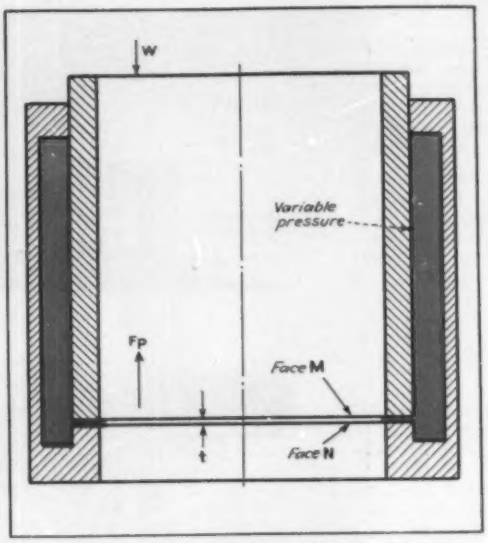


Fig. 4—Stationary setup simulating a mechanical seal for fluid.

τ = shearing stress, psi
μ = absolute viscosity, lb sec per sq in. units
v = leakage velocity, in. per sec
Q_L = leakage volume, cu in. per sec

The relation obtained is

$$p\,(2\pi r_2)\,(2y) = \int_{r_1}^{r_2} \tau\,(2\pi r)\,(2\,dr)$$

$$\text{or } 4\pi p r_2 y = 4\pi \int_{r_1}^{r_2} \tau\, r dr$$

$$\text{since } \tau = \mu \frac{dv}{dy}$$

$$p r_2 y = \mu \int_{r_1}^{r_2} \frac{dv}{dy}\, r dr \qquad (1)$$

Since the flow is laminar, the velocity variation between the faces is parabolic. Therefore,

$$v = v_{max}\left[1 - 4\left(\frac{y}{t}\right)^2\right]$$

$$\text{and } \frac{dv}{dy} = v_{max}\left[-\frac{4}{t^2}(2y)\right] = -\frac{8\,v_{max}y}{t^2} \qquad (2)$$

and since

$$Q_L = (2\pi r t)\left[\frac{2\,v_{max}}{3}\right] = \frac{4}{3}\pi r t\, v_{max}$$

$$v_{max} = \frac{3\,Q_L}{4\pi r t} \qquad (3)$$

substituting Eq (3) in Eq (2)

$$\frac{dv}{dy} = -\frac{6\,Q_L y}{\pi r t^3} \qquad (4)$$

substituting Eq (4) in Eq (1)

$$p r_2 = -\mu \int_{r_1}^{r_2} \frac{6Q_L}{\pi t^3}\, dr$$

integrating

$$p r_2 = -\mu \frac{6\,Q_L}{\pi t^3}\,[r_2 - r_1]$$

or

$$Q_L = -\frac{\pi p r_2 t^3}{6\,\mu\,[r_2 - r_1]} =$$

$$-\frac{\pi r_2 t^3}{6\mu}\left(\frac{p}{r_2 - r_1}\right) \qquad (5)$$

or the leakage per unit of circumference is

$$\frac{Q_L}{2\pi r^2} = -\frac{t^3}{12\,\mu}\,\frac{p}{(r_2 - r_1)} \qquad (6)$$

SURFACE TENSION. The effects of pressure, absolute viscosity, and radial dimensions on the volume of leakage are obvious. The effect of the distance t between the plates, however, is more elusive since it is a cube power. To visualize the effect of t, take two absolutely flat steel plates and place them together with a film of oil between, Fig. 3. After the excess oil has been squeezed out, the oil film will come to equilibrium with a definite film thickness.

Since the film is under pressure caused by the weight of the plate, there must be a force resisting the tendency of the oil to squirt out. Shear cannot exist because the film is stationary, consequently, the only liquid force present is surface tension. At the plate edges the liquid will bulge out hemispherically with surface tension holding it in position as shown in Fig. 3. By taking a length of one inch along the edges of the plates, the forces can be equated in terms of surface tension γ in units of pounds of tensile force per inch of length,

$$pt = 2\gamma \qquad (7)$$

In Table I are given equilibrium conditions of p and t for lube oil and for propane.

The same static condition can also exist with stationary seal faces. In Fig. 4, a set-up simulating a seal is shown. Here again, faces M and N are assumed to be perfectly flat. The tube in the center is free to move vertically

Table I—Equilibrium Conditions for Lube Oil and Propane

t, in.	Pressure p, psi	
	Lube Oil	Propane at 100 F
0.001	0.422	0.057
0.0001	4.22	0.573
0.00001	42.2	5.73
0.000001	422.	57.3

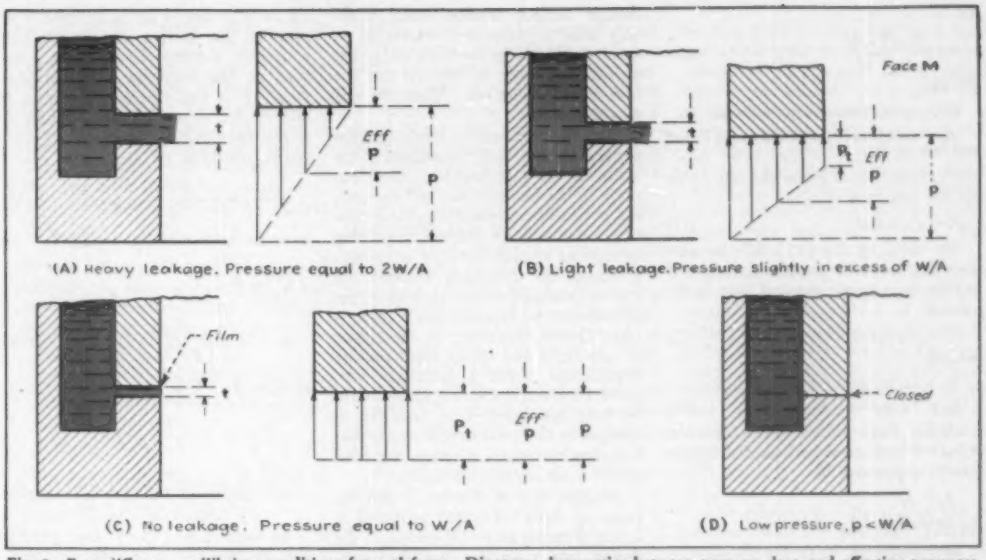


Fig. 5—Four different equilibrium conditions for seal faces. Diagrams show ratios between pressure drop and effective pressures.

and is held down by its weight W only. The vessel surrounding the tube is full of liquid under a variable pressure. If the pressure times the contact area A of the faces was made exactly equal to the weight W of the tube, the tube would come to equilibrium with a gap equal to $2\ \gamma/p$ as shown in Fig. 5 (C). Surface tension would retain the liquid and there would be no leakage. The pressure would be equal to p across the entire face.

If the pressure was decreased, the liquid would no longer be able to support the weight and the tube would drop as in Fig. 5 (D). All liquid would eventually be excluded leaving the faces dry.

By increasing p to twice W/A, the tube would rise. Surface tension would no longer be of importance. The leakage would be heavy and the pressure distribution would drop approximately linearly from full p to atmospheric across the face as shown in Fig. 5(A). If the liquid pressure was made to be an in between value, Fig. 5(B), the tube would drop to an intermediate position. Surface tension would not be able to retain completely the pressure; but because of the force required constantly to keep the film broken, the film would act as a throttle. The pressure distribution would drop from p to some value close to $2\ \gamma/t$ at r_1, and as the leakage passes through the broken film, its pressure would abruptly drop to atmospheric. in its action, the broken film may be compared to a sieve; the size of the holes being determined by amount of back pressure it has to retain and the solid part is analogous to the molecular attraction. When the film is acting as a throttle, the pressure inducing leakage is

$$p - (2\ \gamma/t)$$

Effective Pressure. In all equilibrium conditions shown in Fig. 5, except when the faces are dry, the tube weight is supported by the effective liquid pressure p_e at the faces. In Fig. 5(C), no leakage but with surface tension, the effective pressure is equal to the cylinder pressure.

In Fig. 5(A), no surface tension, the effective pressure p_e is some fraction of p. By assuming a linear pressure drop across the faces, integrating the pressure times an incremental area, and dividing by the face area, an expression for the effective pressure p_e can be obtained.

$$W = \pi\,(r_2^2 - r_1^2)\,p_e = \int_{r_1}^{r_2} 2\pi\, r\,dr \left[\frac{p\,(r - r_1)}{(r_2 - r_1)}\right]$$

or
$$p_e = \frac{p\,(2\,r_2 + r_1)}{3\,(r_2 + r_1)} = kp \qquad (8)$$

where k is the ratio

$$k = \frac{2\,r_2 + r_1}{3\,(r_2 + r_1)}$$

as determined by the seal dimensions.

From Eq (8), it is obvious that with a narrow face, k approaches 0.500; with disk, k is 0.666. In normal seal design practice, k is 0.51 to 0.52 approximately.

Surface tension is defined as the ability of a free liquid surface to resist a tensile stress and is a form of molecular attraction. Since the molecules are in a constant state of agitation, it is conceivable that relative motion in the surface as caused by one seal face rotating is of minor importance. This motion is similar in action to a piece of steel moving about the end of a magnet. Regardless of how fast the metal may be traveling, the magnetic force will still be present and acting on the steel. As a result, rotating the tube should not change any of the relations discussed.

The foregoing relations are used for arriving at the following criteria.

Seal Face Proportions. The effective pressure at the seal face for the general case, Fig. 5(B), is arrived at by using Eq (8) for the pressure drop from p to P_t, which corresponds to the pressure drop, and adding it to P_t. The relationship between p, p_e and P_t as shown in Fig. 6 is

$$p_e = P_t + k\,(p - P_t) = kp + P_t(1 - k) \qquad (9)$$

or

$$P_t = 2\ \gamma/t = \frac{p_e - kp}{1 - k}$$

or

$$t = \frac{2\gamma(1-k)}{p_o - kp} \quad (10)$$

Where

F_s = spring force acting on the seal, lb.

A_p = area between shaft sleeve and OD of seal face, sq. in.

the external force F_e on the other side of the seal face is

$$F_e = F_s + p A_p \quad (11)$$

By dividing Eq (11) by the face area A_e, the unit pressure S_e imposed on the face by the external load is obtained

$$S_e = (F_s/A_e) + p(A_p/A_e) \quad (12)$$

where

P_s = spring force per sq in. of face area

$$S_e = P_s + p(A_p/A_e) \quad (13)$$

If the faces do not touch, then the external load must be balanced by the effective pressure or

$$p_e = S_e$$

or from Eqs (9) and (13)

$$kp + P_i(1-k) = P_s + p(A_p/A_e) \quad (14)$$

The relationship established by Eq (14) shows that the effective pressure will adjust itself by establishing a gap that will build P_i up to a proper amount, since it is the only quantity that can change. With contact loads only slightly above kp, the gap will be large and surface tension will be negligible. As S_e approaches p, the gap will close with the skin influence becoming more important until the surface tension is finally able to withstand the full pressure. Then flow ceases completely.

Note that S_e can vary only between kp and p. If S_e is less than kp, the seal will blow open; conversely, if S_e is greater than p, there is not enough pressure at the face available to maintain a gap and the faces will rub. Even though surface tension could probably hold a pressure in excess of p, there would not be anything to hold it on the liquid side of the seal and the film would squirt out. Then the seal would run dry.

Since the pressure rise resulting from surface tension, and consequently the width of the gap, are determined entirely by the face pressure and the sealing pressure, the operating characteristics of the seal are defined completely as soon as a value for S_e/p is chosen. It makes no difference whether the load is produced by the springs or the pressure on the exposed area. There is some liberty, therefore, in the choice of area ratios and spring force for any application. From a practical viewpoint, however, the spring force should be kept low since it is sensitive to changes in the axial length and manufacturing variations, whereas, the areas can be made to close tolerances.

Another fact of interest is that the faces are fully lubricated provided S_e is not in excess of p. Of course, if the design gap is smaller than the variation in the flatness of the faces, the points of contact will be dry. In this instance, either the flatness of the faces must be improved or the contact pressure must be reduced to increase the design gap. As indicated previously there is a limit, however, in how much the contact pressure can be reduced. As a result, if a correctly designed seal leaks excessively or is operating hot, there may be no alternative but to relap the faces or else let them wear flat. There is no design trick that would enable a seal to run satisfactorily if its faces are not sufficiently flat.

With this evaluation for the size of the gap, it is possible to explore the leakage Eq (6). For t, the term $2\gamma/P_i$ can be substituted. However, for the pressure inducing leakage, the value $(p - P_i)$ should be used, since it is assumed that surface tension acts like a throttle, thereby elevating the pressure on the discharge side. In that event, it is the difference between p and P_i that causes leakage. Where L is the face width, therefore, Eq (6) can be rewritten as

$$\frac{Q_L}{2\pi r_3} = -\frac{2\gamma^3(p - P_i)}{3\mu P_i^3 L} \quad (15)$$

or from Eq 9, when p_e equals S_e,

$$\frac{Q_L}{2\pi r_3} =$$

$$-\frac{2\gamma^3[1-(S_e/p)](1-k)^3}{3\mu L p^3[(S_e/p)-k]^3} \quad (15A)$$

or from Eq (13)

$$\frac{Q_L}{2\pi r_3} = -\frac{2\gamma^3}{3\mu L p^3} \times$$

$$\frac{[1-(P_s/p)-(A_p/A_e)](1-k)^3}{[(P_s/p)+(A_p/A_e)-k]^3} \quad (15B)$$

In both Eqs (15*A*) and (15*B*), the variables appear in both the numerator and the denominator so that the relation is not simple. By differentiation with p, it can be shown that $Q_L/2\pi r_3$ has a maximum value when

$$\frac{p}{P_s} =$$

$$\frac{1+2(A_p/A_e)-3k}{2[(A_p/A_e)(1+k)-(A_p/A_e)^2-k]} \quad (16)$$

With normal seals, the maximum leakage occurs when the liquid pressure is about eight to ten times the contact pressure of the springs only. When the liquid pressure falls below this value, the effective pressure inducing leakage falls off rapidly, while at the same time the spring force is becoming more predominate, with the result that the gap is closing. If the pressure is reduced below a certain value, the effective leakage pressure is zero and there would not be any leakage at all. If the pressure would be reduced still more, then the pressure at the face of the seal would be unable to counteract the spring and the faces would run dry.

When the liquid pressure is greater than the critical value, it seems that the cube of the gap decreases more rapidly than the pressure rise, with the result that leakage is decreased. With a still further increase in pressure, the leakage continues to decrease and approaches a finite quantity asymptotically.

Of special interest are the face ratios one-half and one, which deviate from the general trend. With a face ratio of one-half the leakage curve has no peak; the curve increases contin-

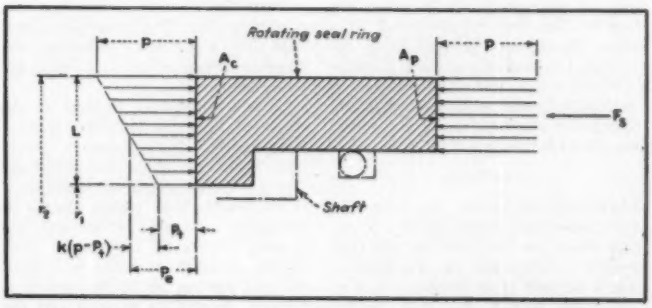


Fig. 6—Mechanical and hydraulic forces acting on a rotating seal ring in equilibrium.

uously as the pressure rises. Apparently at all times, the effective pressure increases quicker than the cube of the gap decreases. When the faces are equal, the seal always run dry since the liquid pressure is not sufficient to balance the spring force. By removing the springs, however, the pressure at the face will always be equal to p, thus theoretically the seal will never leak.

POWER INPUT. With a film of liquid between the faces and with no actual contact, the only work done is in shearing the film, or where

F = force, lb
μ = absolute viscosity, lb sec per sq in. units
V = mean velocity of rotating face, in. per sec

$$F = \mu A V/t \qquad (17)$$

For design purposes, it is desirable to state this relation in terms of unit length of circumference

$$\frac{F}{2\pi r_1} = \frac{\mu L V}{t} \qquad (17A)$$

to be absolutely correct, L in Eq (17A) should be multiplied by

$$[(r_1^2/r_2^2) + 1]/2$$

but since this factor is nearly unity, it is here ignored.

By using $2\gamma/P_i$ from Eq (9) in Eq (17A) and multiplying by V the power equation, where H_i is horsepower input per inch of circumference, can be expressed as

$$H_i = \frac{\mu L V^2 P_i}{6{,}600\,\gamma} \qquad (18)$$

$$= \frac{\mu L V^2 p\,[(P_o/p) + (A_p/A_o) - k]}{6{,}600\,\gamma\,(1-k)} \qquad (18A)$$

The temperature rise of the liquid in passing between the faces is proportional to the work done on each unit volume of leakage.

Where

w = liquid weight, lb per cu in.
ΔT = temperature rise, deg F
C = specific heat, Btu per deg F per lb

an expression for temperature rise ΔT is obtained by dividing Eq (18A) by Eq (15B)

$$\Delta T = 64.8 \times \frac{\mu^2 L^2 V^2 p^2\,[(A_p/A_o) + (P_o/p) - k]^2}{w\,\gamma\,^4C\,(1-k)^2\,[1 - (P_o/p) - (A_p/A_o)]} \qquad (19)$$

The absolute value of ΔT is of minor importance. Loss of heat through conduction and other unknown variables can greatly affect the actual temperature. The expression Eq (19), however, does indicate the relative influence of the various terms.

The liquid properties are present as $\mu^2/C\,\gamma^4$. Of the four quantities, viscosity is subject to the most variation between different liquids, and as a result is the most important. This relationship seems to indicate that a seal operating in a viscous liquid like oil should be warmer than one in water or some other light fluid. The face width L is present to the square power. Apparently, the face should not be any wider than absolutely necessary. By doubling the face width, the temperature rise should be quadrupled. The speed is also present to the square power. This term, however, usually cannot be changed since it is fixed by the shaft diameter and speed. The remainder of the expression is associated with no obvious trend.

By differentiating Eq (19) with respect to p a minimum value of T is obtained when

$$\frac{p}{P_o} = \frac{1 + 3\,(A_p/A_o) - 4\,k}{3\,[(A_p/A_o)\,(1+k) - (A_p/A_o)^2 - k]}$$

These values are nearly the same as those for maximum leakage. With conventional seals, they occur when the liquid pressure is from six to eight times the contact pressure with springs only.

VOLATILE LIQUID SEALS. Seals for volatile liquids that are in a vapor state at atmospheric conditions require special consideration. The main requirement is that the liquid is retained in a fluid state over the entire face. If this requirement is not fulfilled, there may be fluid over part of the face and vapor over the remainder. Since most liquids expand to enormous volumes in vaporizing, any leakage would be greatly accelerated.

By making the contact pressure P of such a magnitude that at the lowest operating pressure the contact pressure is slightly in excess of the vapor pressure at the prevailing temperature, the liquid can be kept from changing state. Then, for all intents and purposes, the seal will operate in a normal fashion. It is not desirable that P be much greater than the vapor pressure because of the possibility of the faces contacting. It must be borne in mind, however, that the faces must be flat enough so that a gap corresponding to the design P can be attained; otherwise, the seal will not hold.

ACTUAL SEALS. In the development of the foregoing theory, it was assumed that the faces were perfectly flat, that is, they must be separated by a finite gap at all times to obtain lubrication; otherwise, they would be in perfect contact and exclude the liquid. This condition was achieved by making the contact pressure some value less than the liquid pressure. With actual seals, however, the degree of flatness desired may not always be attainable commercially with the result that the gap is more likely determined by the waviness of the faces.

This condition, in turn, will establish the back pressure in accordance with Eq (7) regardless of the magnitude of the theoretical load. The difference between the external force produced by the springs and the liquid pressure and the force exerted on the face by the leakage must then be carried by the high points. The leakage will still be determined by Eq (5), but the gap must be assumed to be a constant.

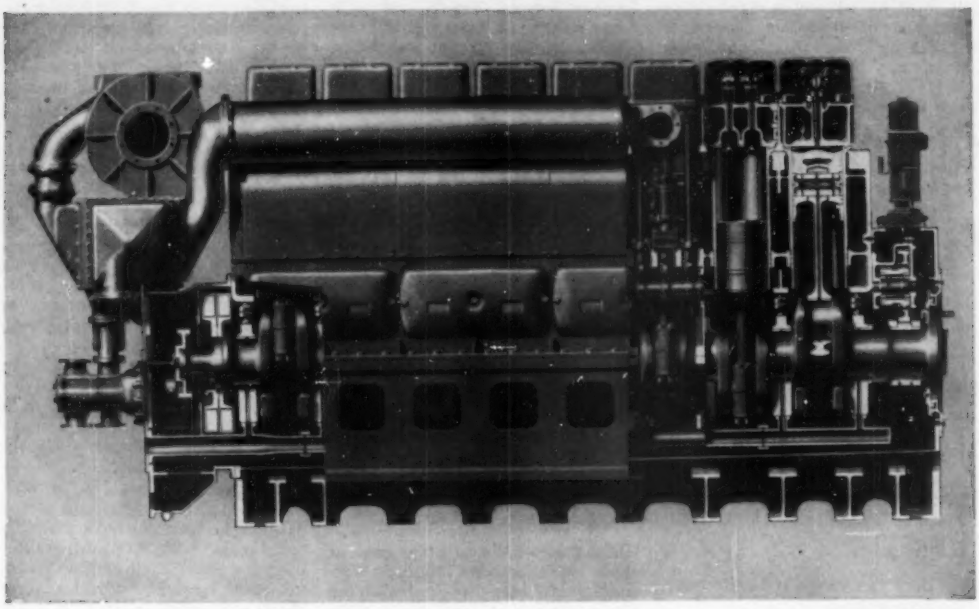
The amount of rubbing that can be tolerated with any given seal is apparently affected by the face materials, the liquid, and the velocity.

Most commercial seals on low pressure, when a high P_o/p value is needed to offset the spring force, operate with actual contact. The fact that reasonable operating life is readily obtained seems to indicate, however, that with a proper choice of materials the seals can be expected to operate satisfactorily even with appreciable waviness in the faces.

With high pressure seals the condition and the materials of the faces become relatively more important. A seal that operates satisfactorily at low pressures may not necessarily be suitable at higher loads. The same is true of volatile liquid seals. It is imperative that the gap, and consequently the departures from flatness of the face, be sufficiently small to produce the proper back pressure.

COMMENT. The author does not recollect ever seeing a discussion of mechanical seals using molecular attractions as a basis for design. The actual existence of a microscopic gap as indicated in the theory is difficult to ascertain directly. Its presence, however, can be arrived at by deduction and it gives the only plausible explanation of why a seal works with volatile liquids. The close interrelationship between the liquid's vapor pressure and the theoretical back pressure created by surface tension has definitely been indicated in a few experimental seals.

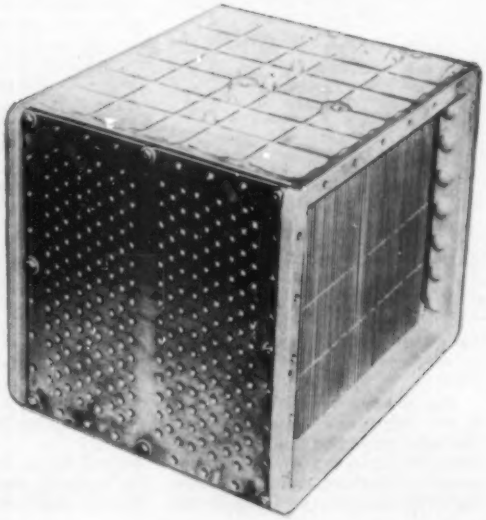
It is hoped that the basic equations derived here for leakage of fluid through an axial gap will serve as an approach to the solution of the many complex problems associated with the design of mechanical seals.



TO KEEP WEIGHT DOWN, all major structural parts are fabricated by welding. The 8 cylinder engine shown develops 1,200 hp at 950 rpm. It is 4-cycle, supercharged. Removable cylinder liners are used. For stability, the camshaft drive is taken from the flywheel end of the crankshaft. Pumps are driven from the free end.

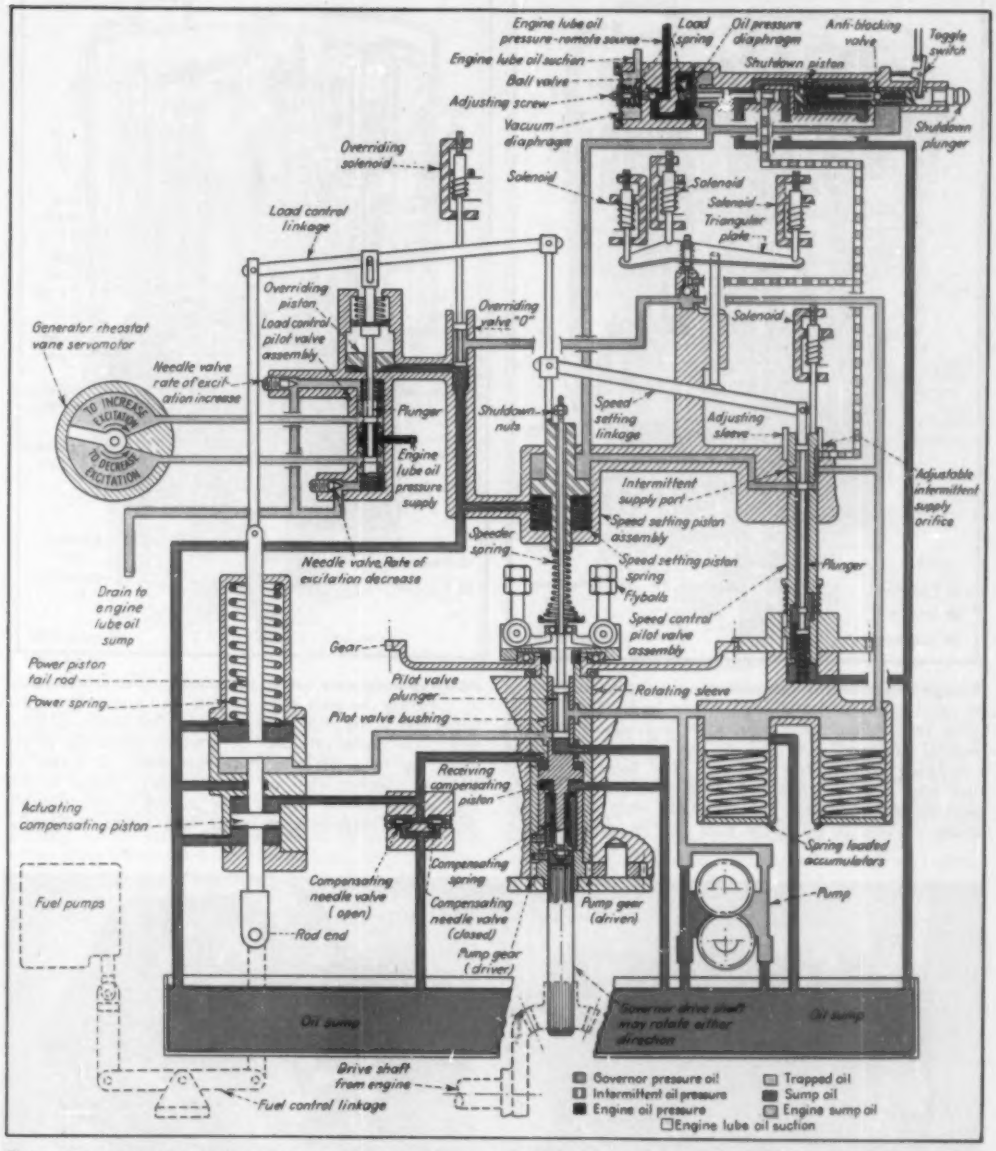
Electro-Hydraulic Controls for Diesel

The 8 in-line cylinders of the Lima-Hamilton T-89-SA engine develops 1,200 hp for locomotive, marine or stationary applications. The engine is designed for use with a Woodward governor. This electro-hydraulic device serves as speed selector, governs rpm and protects against improper operation and oil pressure failure. Heavy plates, shapes and forgings make up the welded block of the 9x12 in. cylinders. For easy servicing, the cylinders liners, main crankshaft bearings, cylinder heads and connecting rods are individually removable. A water-cooled exhaust line leads to the turbo-charger. The engine is made by the Hooven Owens Rentschler Division of the Lima-Hamilton Corporation in Hamilton, Ohio.



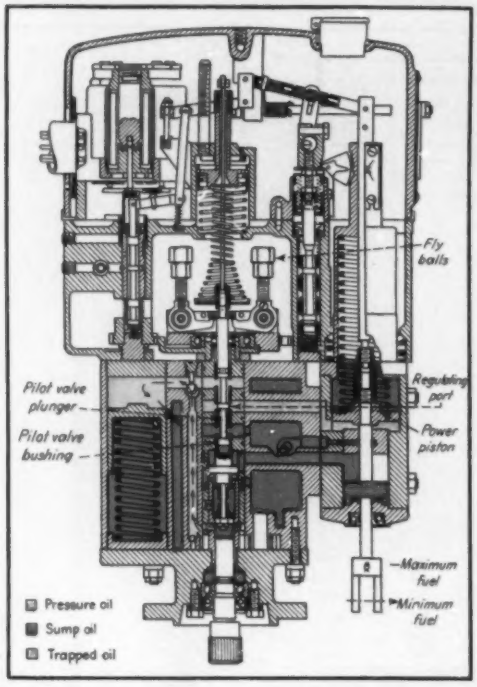
HEAT EXCHANGER COOLS INTAKE AIR to increase engine output. Water circulates through the exchanger core, which is located between the supercharger and the intake header. An exhaust driven turbine powers supercharging compressor.

D E S I G N S

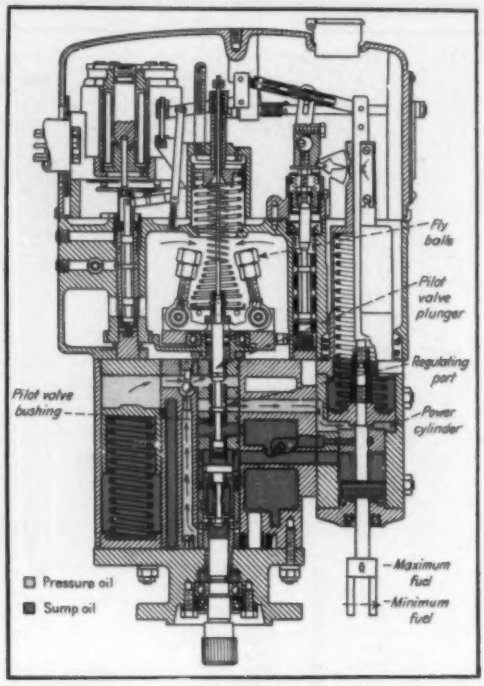


ELECTRO-HYDRAULIC GOVERNOR REGULATES ENGINE SPEED by varying the fuel supply. A number of auxiliary devices, such as solenoids, valves and pistons, are incorporated in the governor to provide remote control of engine speed settings; limiting of engine loads under certain operating conditions; protection against lubricating oil failure and protection against careless operation. When engine is shut down by lubricating oil pressure failure, an adjustable time delay arrangement allows restarting of the engine without oil pressure. But it will shut down again if oil pressure is not established within a certain time. Should the shutdown plunger be held in manually when shutdown mechanism is functioning, the anti-blocking valve bypasses the oil above the speed control piston to sump, actuating governor pilot valve. The Woodward governor provides remote electrical speed control in any number of steps up to 14, plus shutdown and idling.

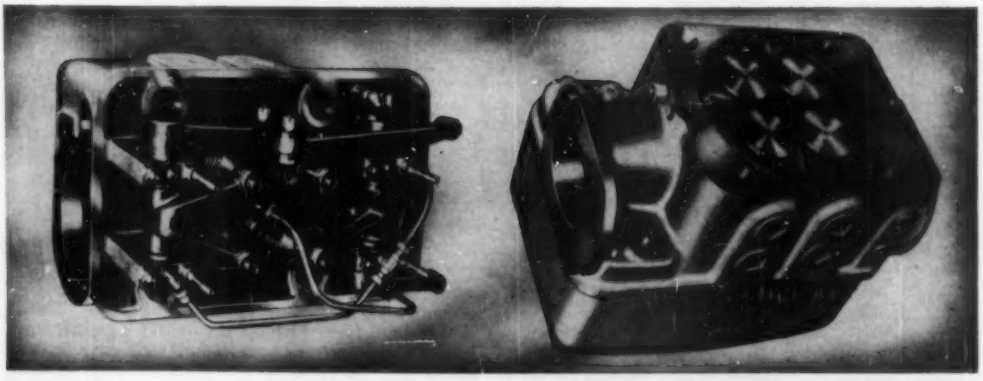
(*continued on next page*)



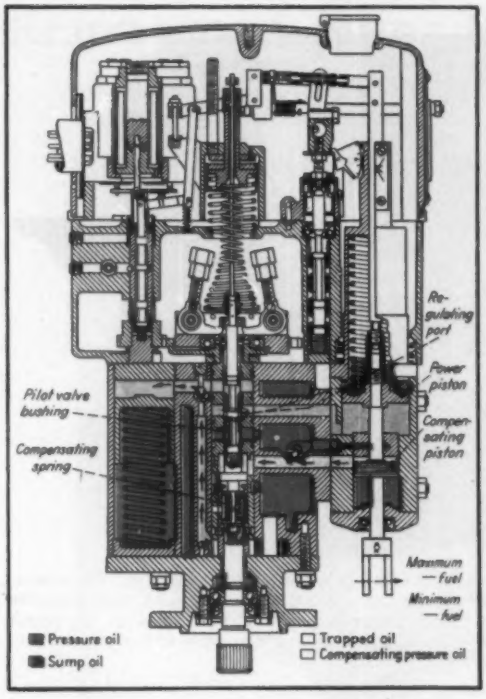
UNDER EQUILIBRIUM CONDITIONS, the engine is running at rated speed under a small steady load. The flyballs, pilot valve plunger and pilot valve bushing are in their normal positions. A land on the plunger covers the regulating port in the bushing. The power piston is stationary near the minimum load position. Following sketches show sequence of operation when load is increased. SAE 20 oil is the fluid that is normally used.



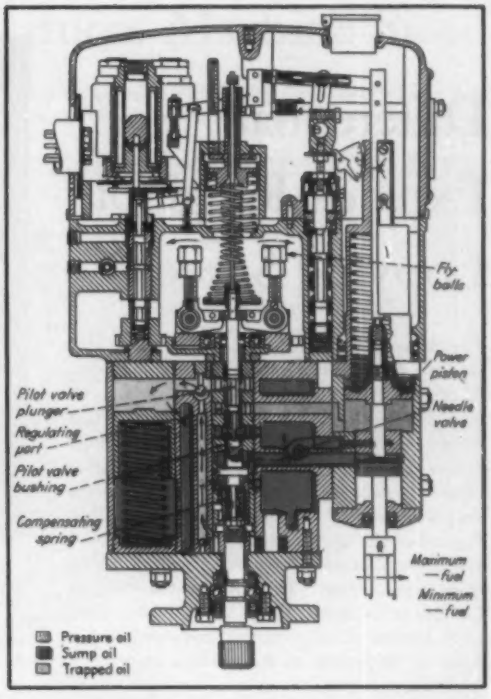
AS LOAD INCREASES, SPEED DECREASES. The flyballs move in, lowering the pilot valve plunger, and uncovering regulating port in the pilot valve bushing. This admits oil pressure to the power cylinder. Oil pressure moves the power piston up in order to increase fuel flow. A system of linkages connects the rod of the power piston to the fuel pump control valves. The governor speed setting depends on magnitude of spring load acting on flyballs.



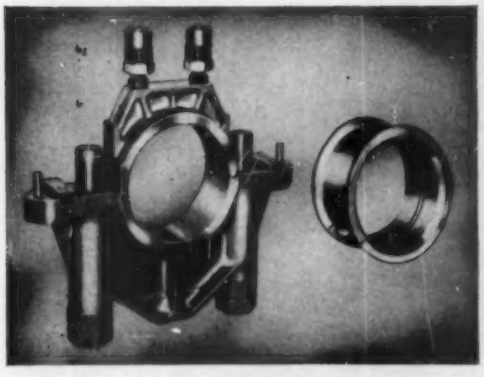
CYLINDER HEADS ARE MEEHANITE castings. All moving parts are secured to the cylinder head and completely enclosed. Heads contain two exhaust and two inlet valves of the same size. Valve seat inserts are provided for all valves. The cylinder heads can be tightened without removal of the valve gear. Oil under pressure lubricates all working parts. Lubricating oil returns to the crankcase through the valve push rod casing.



UPWARD MOVEMENT OF POWER PISTON moves the compensating piston up, also. This forces pilot valve bushing down, compressing compensating spring. This continues until the regulating port in the bushing is covered by the land on the plunger. As soon as the regulating port is covered, the power piston is stopped at a position corresponding to the increased fuel needed to run engine at rated speed under the added load placed on the engine.



AS THE SPEED RISES, the flyballs return to their normal positions. This raises pilot valve plunger to its normal position. The pilot valve bushing is returned to normal position by the compensating spring at the same rate as the pilot valve plunger, thus keeping power piston and the regulating port in bushing covered by plunger land stationary. Needle valve determines rate at which bushing returns to normal. Equilibrium conditions are again in effect.

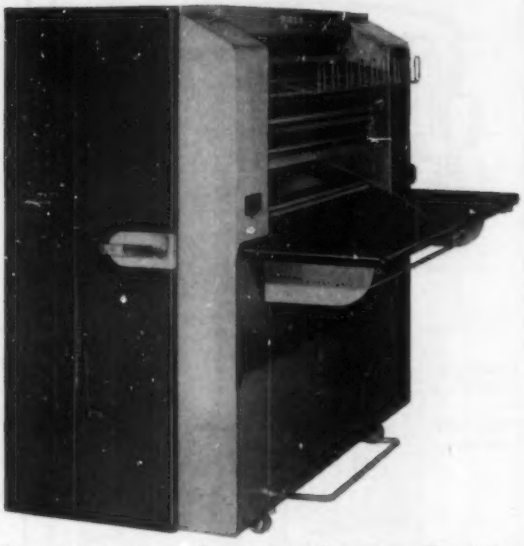


JACK BOLTS hold the main crankshaft bearing caps in place. This makes it possible to remove the shells of the bearing for inspection without disturbing the bearing saddles. Bearings are accessible through holes in the cylinder block.

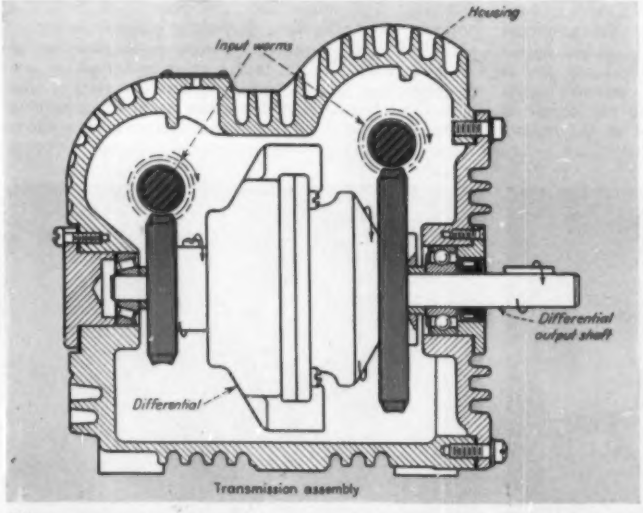
ONE HOUSING contains oil pressure pump and scavenging pump. The first pump supplies lubricating oil to the engine through filters. The scavenging pump of similar capacity transfers oil from crankcase to an external tank.

Differential Extends Range of Copying Speeds

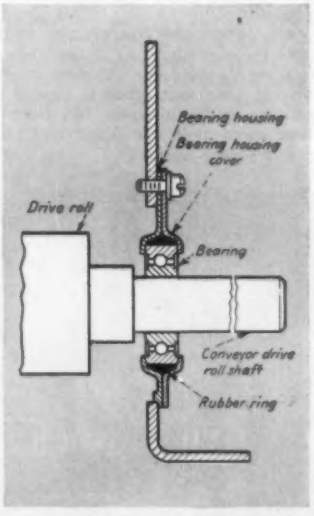
The Bruning Model 50 Whiteprinter is a high capacity duplicating machine for drafting room or office work. Output of the new machine is almost 3 times that of its predecessor but the cost is only slightly more. The combination of high output and low cost is the result of using higher capacity components (lamp, drive motor, fan, etc.) while simplifying design wherever possible. Feature of the new machine is a variable speed mechanism that provides copying speeds ranging from 0 to 24 fpm. The Bruning Company of Chicago states that redesign lowered labor costs to 10 percent of the total cost, compared with a figure of 40 percent on the previous model.



CABINET REDESIGN was first step toward economy. The elimination of complicated contours, ball corners and other expensive details shaved cabinet cost from $125.00 to $46.00. To permit volume purchasing, identical motors were selected for fan and drive.



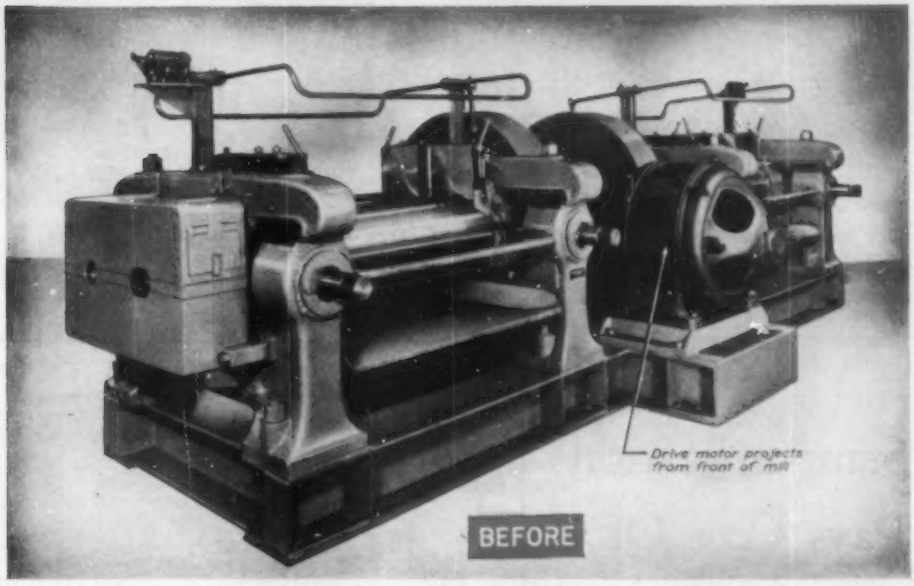
VARIABLE SPEED TRANSMISSION consists of two sets of worm gearing feeding into a differential mechanism. Output shaft speed depends on difference in rpm between the two input worms. When worm speeds are equal, output is zero. Each worm shaft carries a cone-shaped pulley. These pulleys are mounted so that their tapers are in opposite directions. Shifting the position of the drive belt on these pulleys has a compound effect on output speed.



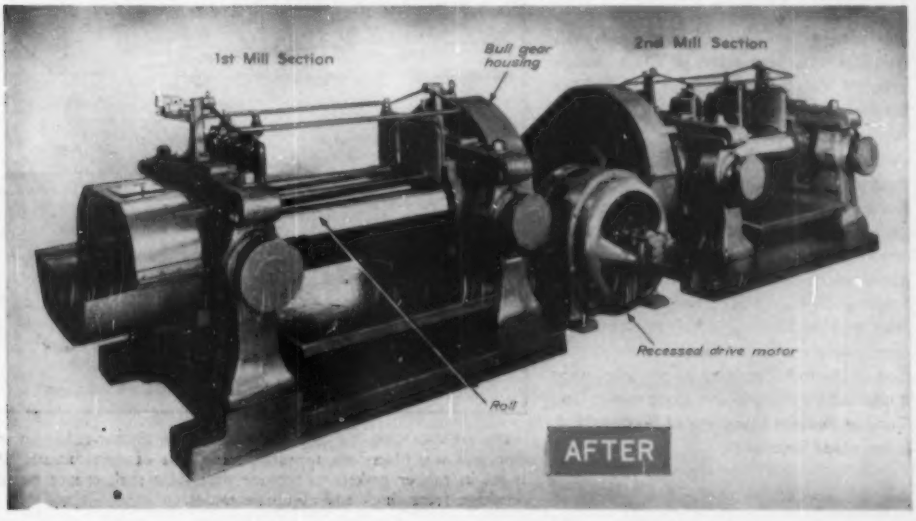
BALL BEARINGS set in a self-aligning mounting carry the drive rolls. Higher cost of these bearings over original sleeve bearings was more than offset by simplicity of mounting and shorter assembly time needed.

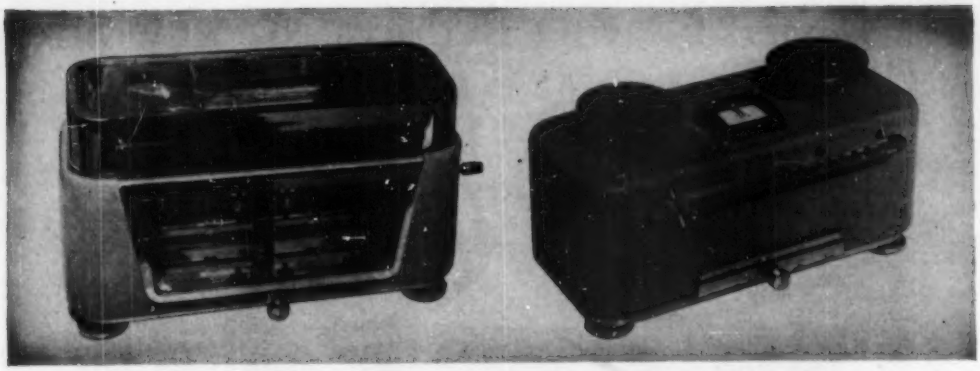
Rearranged Gearing Reduces Machine Size

The Adamson United Company of Akron aims always to minimize the factory floor space needed for machines they build. That was the motive behind redesign of this roll mill for use in rubber processing.



A 250 HP MOTOR drives both sections through a right angle speed reducer with a double-ended output shaft. The conventional reducer originally used needed at least 30 in. between pinion and driven gear centers to carry the load. This necessitated a horizontal arrangement of reducer gearing so that the motor projected from the front of the mill. The Cone-Drive gear set of the same capacity now used has only 18 in. between centers. A vertical gear arrangement is now possible so the motor fits in under the reducer.

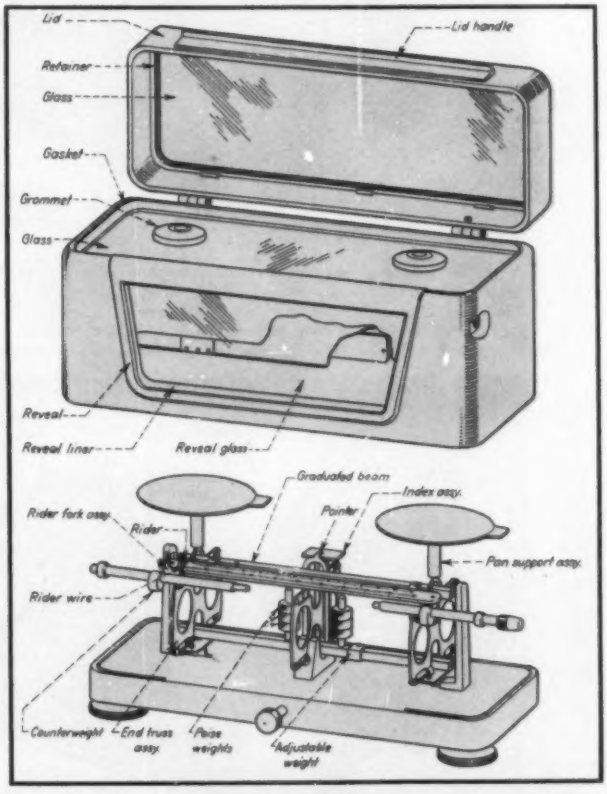




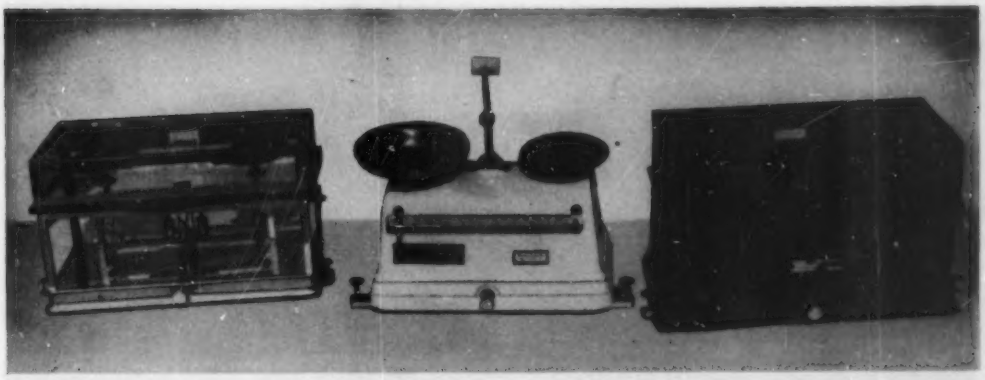
NEW BALANCES HAVE GREATLY IMPROVED APPEARANCE because of smooth lines and rounded edges and corners. Balance on left is used in the drug trade for compounding prescriptions. Hinged cover prevents atmospheric dust from contaminating materials being weighed. Second balance has no cover and is suitable for general laboratory service where purity is not a factor. A stainless steel balance for dairy industry is made with same dies.

Standardization Pays Cost Of Streamlining

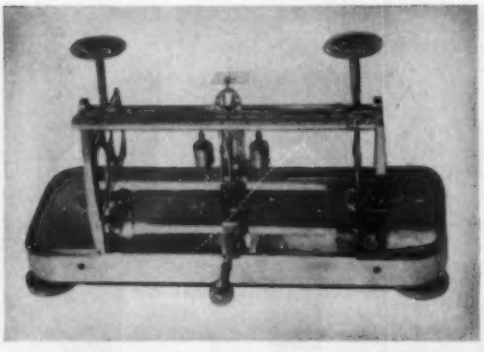
Added sales appeal as well as production economies were gained in the redesign of this line of prescription and laboratory balances. First step taken by Clare Hodgeman of the Raymond Loewy Associates was to standardize the basic case structure for all models. Originally 4 different cases were used and the volume of production did not justify tooling costs. Cases were more or less hand made. Standardization made the purchase of drawing dies economical. Variations in the external appearances of the several models are achieved by use of glass panels, chromium trim and distinctive metal finishes. Another feature of the redesign is the relocation of the index pointer on the laboratory model under a protective glass cover. The Torsion Balance Company of Nutley, N. J. is the manufacturer.



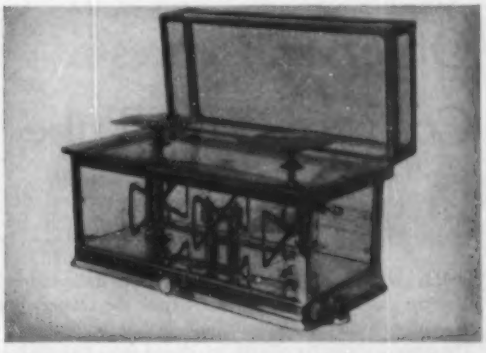
BASIC MECHANISM OF BALANCE REMAINS unchanged. In redesign, emphasis was placed on appearance and ease of manufacture. All glass is set in rubber gaskets to provide dust tight seal, reduce possibility of breakage from shock and eliminate rattles.



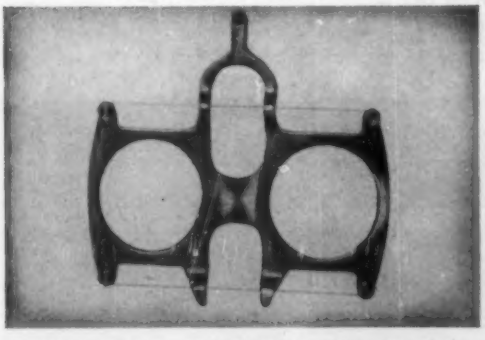
BEFORE REDESIGN, four different cases were produced. Three are shown here. Deluxe and standard cases for the prescription balance were of steel framed glass and wood construction, respectively. Laboratory balance in center was enclosed in a cast iron housing that was coated with porcelain enamel. Each case involved completely different production procedures. The lack of volume "runs" made for higher manufacturing costs.



FOR READABILITY AND APPEARANCE, scale markings are in two colors. Divisions of the gram scale are black. Red is used for the graduated markings of the grain scale.

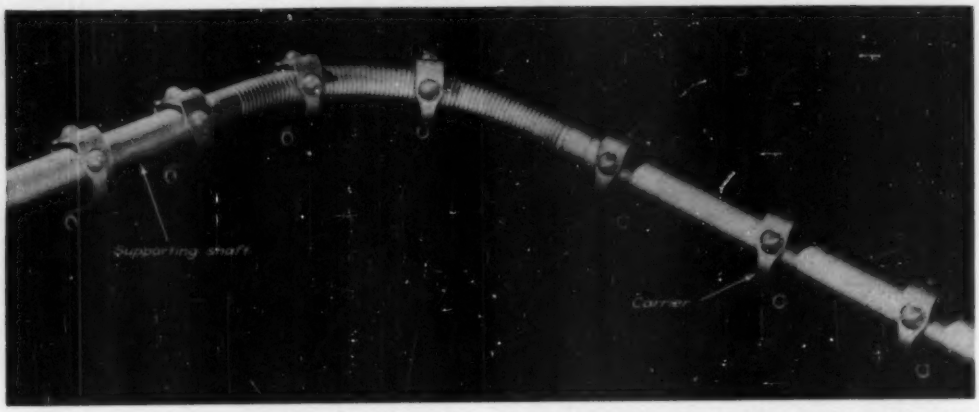


STEEL FRAME OF OLD CASE was buffed and chromium plated. Buffing process often warped the frame, making installation of the glass panes extremely difficult.



TRUSS IS A ONE PIECE STAMPING. Balance mechanism pivots on the truss wires which approximate frictionless bearings. Because mechanism is visible through case window, appearance was considered in truss design.

THREE DRAWS ARE REQUIRED FOR THE CASE. For prescription balance, window opening and entire bottom are punched out. For laboratory balance, trimming and piercing are only operations required.

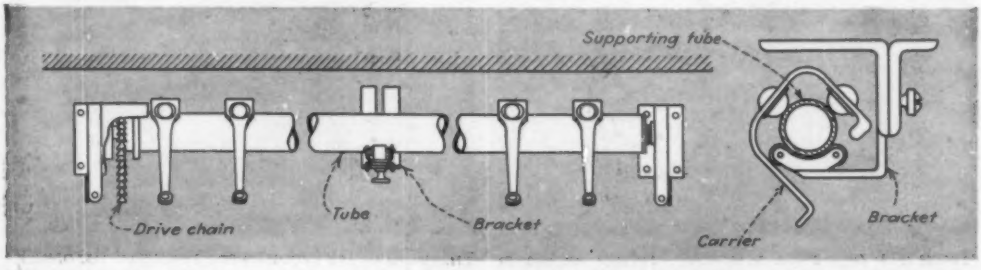


ROTATION OF THE SUPPORTING TUBE causes the carriers to travel along its length. Reversing the direction of tube rotation also reverses carrier travel. Traverse pictured above is for window drapery or stage curtain applications. Drapes hung on the carriers are opened and closed by rotation of the tube. Carriers are die cast.

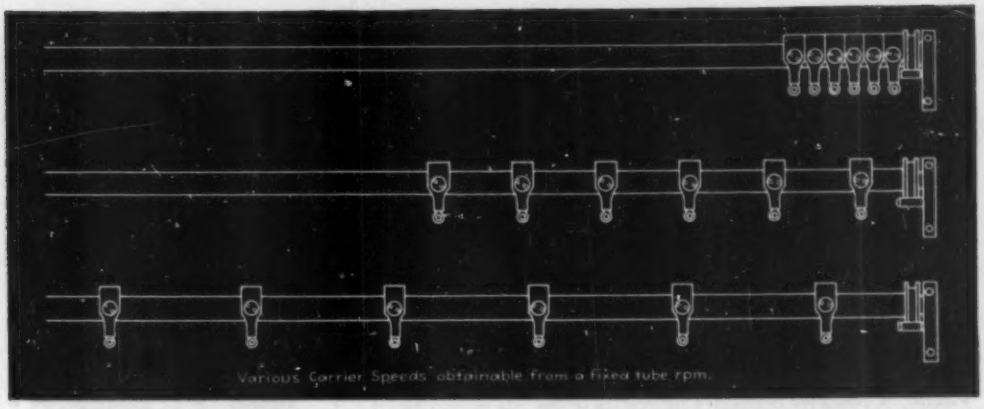
Offset Ball Axes Convert Plain Tube Into Lead Screw

In this conveyor system, all carriers move independently along a rotating shaft. For a fixed shaft rpm, the carriers can travel at the same or different speeds, and in like or opposite directions. The action is similar to that produced by a screw—but the shaft has a plain surface. Each carrier has two plastic balls whose axes are set at an angle with the shaft axis. The Bradley Rotor Traverse Co., Inc., of Staten Island 2, N. Y. says the mechanism simulates a lead screw having an infinite number of threads of various pitch, both right and left hand. A horizontal component of friction pushes the carriers along the tube.

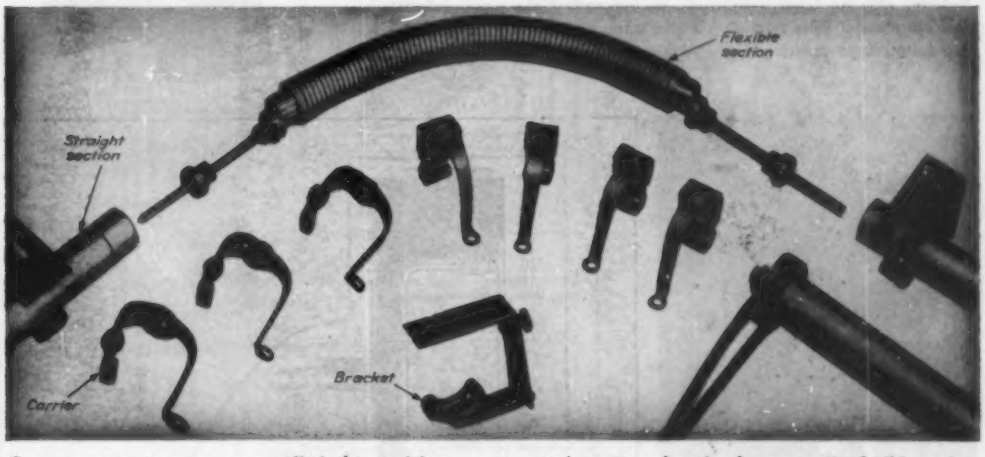
BALL AXIS IS OFFSET FROM TUBE AXIS. This arrangement breaks up the friction between ball and tube into 2 component forces.



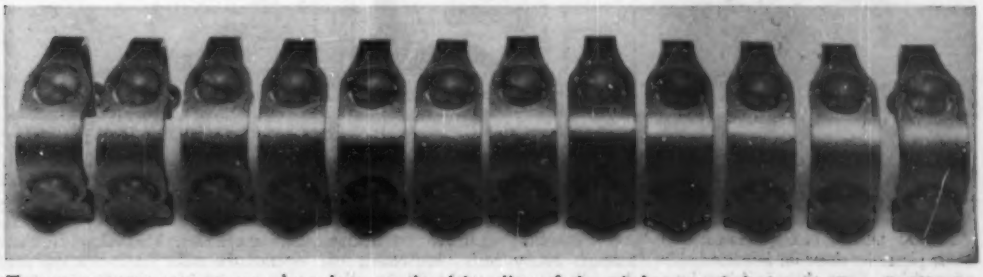
ROTATABLE TUBE MAY BE OF ANY LENGTH. Brackets equipped with roller cradles support the tube at intervals. Tube is rotated by means of a pulley or sprocket at one end. In the drapery application, the tube may be motor driven or operated by a hand chain. Tube is coated with a long-wearing plastic finish.



SPEED OF CARRIER MOVEMENT depends on two factors—tube rpm and the amount of the angle between ball axis and tube axis. As illustrated above, it is possible to obtain a variety of carrier speeds from a fixed rate of tube rotation. This is done by using carriers whose ball axes are set at various angles with the tube centerline.

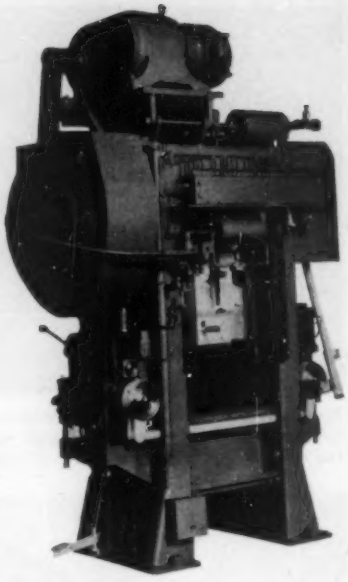


CONVEYOR INSTALLATIONS are not limited to straight runs. A flexible tubular section of special design is used at corners or whenever turns are to be made. A series of ball bearings, mounted on a curved steel rod, supports the flexible section. The rod projects a few in. into the straight sections. Tubes and flexible section rotate as a unit.



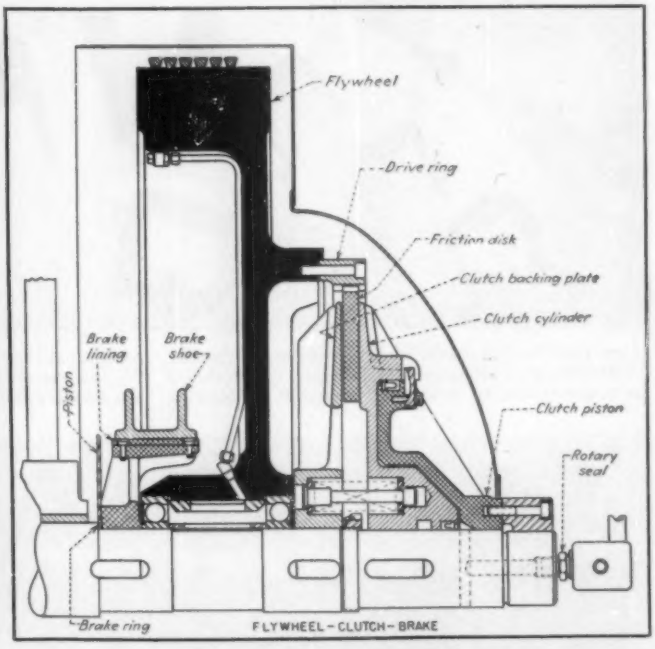
TWELVE CARRIERS SHOWN carry drape hung on the right side of a window. A second set carries the left hand drape. Ball axes are set so all carriers move toward the centerline of the window on clockwise rotation of the tube. Carrier speeds are arranged so that folds in the draperies are always of equal width.

Pneumatic Clutch-Brake Unit Controls Press Cycle

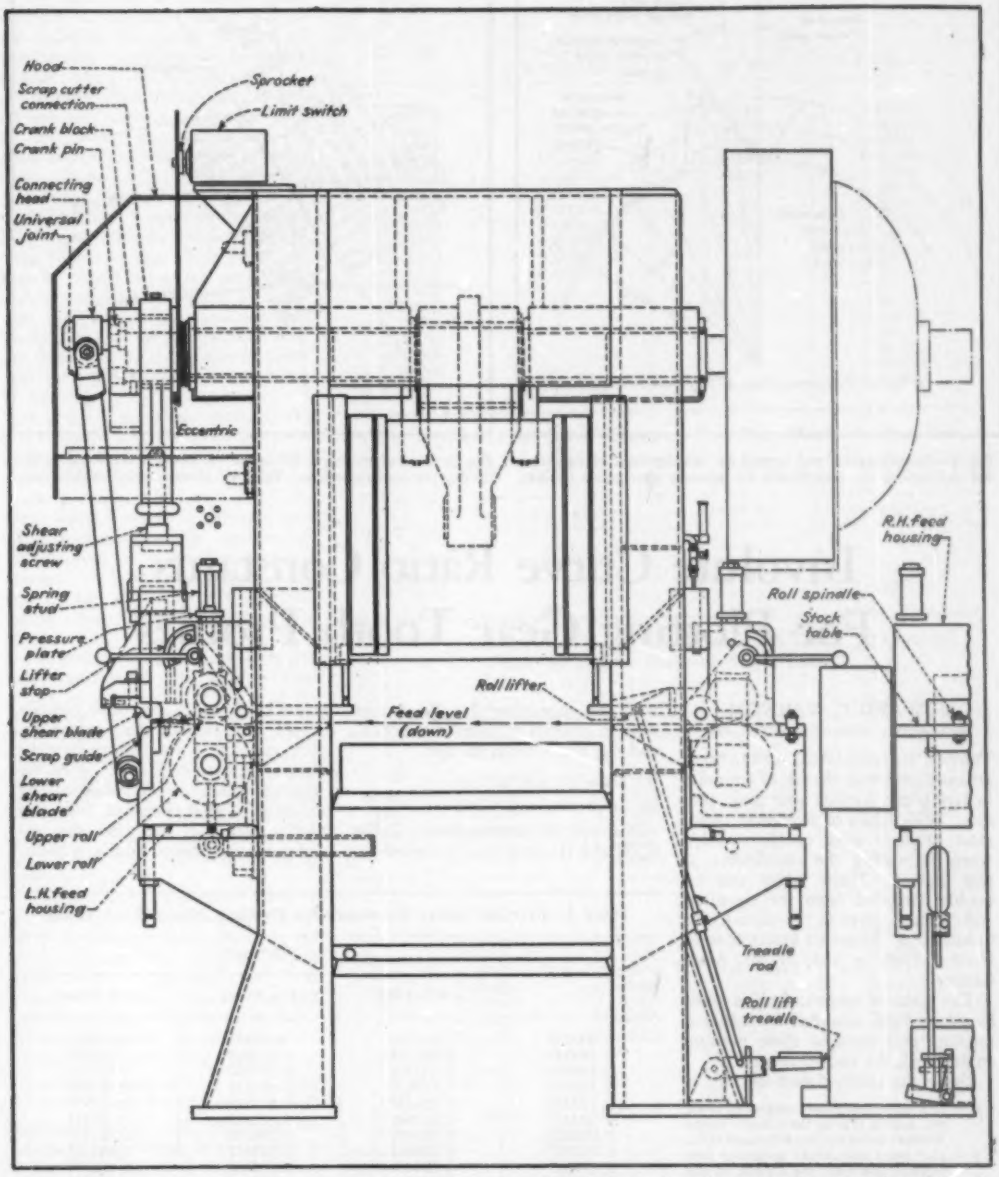


Warco punch presses are made in various sizes from 75 tons up to 200 tons. They are high speed, flywheel actuated units operating as fast as 225 strokes per min. To obtain these high speeds with a minimum of noise and shock, engineers selected an air operated friction clutch rather than a positive type clutch. The air clutch is more expensive than the latter but it is more adaptable to remote control and to the incorporation of safety features. The one piece welded frame gives stiffness in both vertical and horizontal planes. A variable speed reducer drives the flywheel through a series of V-belts. A pump-fed centralized lubrication system oils all moving parts. Presses are equipped with a two-way adjustment to take up wear and play in the ram slide. The Federal Machine and Welder Company of Warren, Ohio, builds Warco presses. Unit is driven without gearing from a flywheel, incorporating the air operated friction clutch. This type clutch eliminates severe metallic pounding inherent in positive dog or key type clutches.

AS SCRAP LEAVES PRESS, it is cut into short pieces by shear on left hand side of machine. Scrap shear is driven by a connecting rod from an eccentric on the main shaft.



AIR ENTERS CLUTCH CYLINDER through rotary seal. Movement of the cylinder engages the friction disk with the backing plate. At the same time, air is applied to the brake releasing cylinder. This allows clutch to operate the main shaft. At top dead center, air is released, permitting springs to disengage clutch and operate the brake.



MATERIAL ENTERS PRESS FROM THE RIGHT in strip form. This unit has 3 operating stations—blanking and first and second forming. The feed rollers located on the left side pull the scrap out of the machine. A scrap shear, driven from an eccentric on the main shaft, reduces the scrap. The feed itself is driven by an adjustable eccentric mechanism through a lever connected to a free-wheeling clutch. Backlash in the feed mechanism is prevented by small shoe brakes dragging on the upper rolls. These rolls are spring loaded. The feeding is done during the upper portion of the stroke and requires about 180 deg of travel. The return of the ratchet mechanism takes place on the lower part of the stroke. The feed is synchronized so that its dwell points occur at the mid-point of both upward and downward strokes. The machine is normally stopped at mid-stroke by the air-operated friction clutch. Therefore, the machine does not stop when the feed is moving fastest, i. e., at the middle of its cycle. Cam-operated switches control the solenoid valve that supplies air to the clutch. Cam is adjustable to stop press at any point.

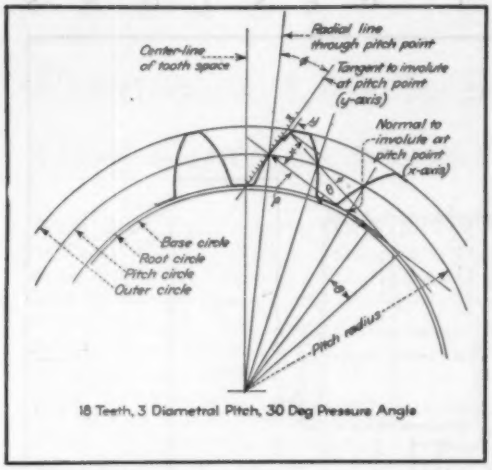

Center-line of tooth space
Radial line through pitch point
Tangent to involute at pitch point (y-axis)
Normal to involute at pitch point (x-axis)
Base circle
Root circle
Pitch circle
Outer circle
Pitch radius
18 Teeth, 3 Diametral Pitch, 30 Deg Pressure Angle

Fig. 1—Nomenclature and legend for development of equations for calculating the coordinates of involute gear tooth profiles.

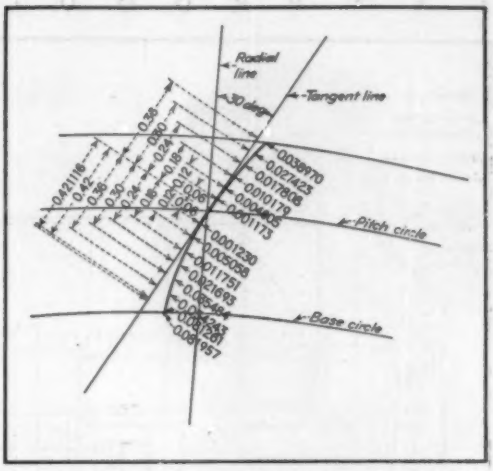


Fig. 2—Plot of tooth profile for an 18 tooth, 3 diametral pitch, 30 deg pressure angle gear. Table IV gives detailed calculations.

Involute Curve Ratio Constants For Plotting Gear Tooth Profiles

EDWARD C. VARNUM
Mathematician, Barber-Colman Company

TEDIOUS MATHEMATICAL OPERATIONS are associated with the use of formulas in laying out involute gear tooth profiles. With tables of numerical ratios, most of such work can be avoided when calculating the coordinates of plot points. These tables can be readily compiled from the equations and constants given in "Involute Curve Calculations," PRODUCT ENGINEERING, October 1949, p. 135, by Mr. Allan Candee.

The tables of numerical ratios given here have been compiled for standard involute gear teeth of three pressure angles; 14½, 20, and 30 degrees.

Using the nomenclature of Fig. 1,

x = plot point coordinate measured along the X-axis, that is, the tangent to the involute curve at the pitch point O, in.
y = plot point coordinate measured perpendicularly from the x-point on the X-axis to the point P on the curve, in.
r = pitch radius of gear, in.
ϕ = pressure angle at pitch point O, deg.
θ = angular displacement of the normal around the base circle, deg.

the formulas for the x and y coordinates as given by Mr. Candee are

$$x = r\,[\sin\phi \sin\theta \pm \cos\phi\,(\theta \sin\theta - \text{vers}\,\theta)] \quad \text{(A1)}$$

$$y = r\,[\sin\phi\,\text{vers}\,\theta \pm \cos\phi\,(\sin\theta - \theta\cos\theta)] \quad \text{(B1)}$$

with the suggestion that the expressions in brackets be called constants C_A and C_B, respectively, so that

$$C_A = x/r, \text{ and } C_B = y/r$$

or $$x = rC_A, \text{ and } y = rC_B$$

In accord with this suggestion, Tables I, II, and III have been compiled for values of C_A and C_B for three pressure angles. For each of the pressure angles, values of θ were chosen to make C_A a convenient multiplier. With the selected values of θ, corresponding values of C_B were calculated. With this tabular data, full size plot point coordinates are obtained simply by multi-

Table I—Involute Curve Constants for Plotting Above Pitch Point

$C_A = x/r$	$C_B = y/r$		
	ϕ = 14½ deg	ϕ = 20 deg	ϕ = 30 deg
0.200000	0.052769	0.044476	0.034581
0.180000	0.043588	0.036569	0.028270
0.160000	0.035208	0.029380	0.022563
0.140000	0.027636	0.022916	0.017467
0.120000	0.020887	0.017189	0.012990
0.100000	0.014983	0.012218	0.009141
0.080000	0.009955	0.008028	0.005936
0.060000	0.005852	0.004653	0.003393
0.050000	0.004167	0.003285	0.002377
0.040000	0.002742	0.002140	0.001535
0.030000	0.001591	0.001228	0.000872
0.020000	0.000732	0.000557	0.000391
0.018000	0.000598	0.000453	0.000318
0.016000	0.000476	0.000360	0.000251
0.014000	0.000367	0.000277	0.000193
0.012000	0.000272	0.000204	0.000142
0.010000	0.000191	0.000143	0.000099
0.008000	0.000123	0.000092	0.000063
0.006000	0.000070	0.000052	0.000036
0.004000	0.000031	0.000023	0.000016
0.002000	0.000008	0.000006	0.000004

plying C_A and C_B by the pitch radius of the gear. As an additional convenience in calculation, the C_A values are in equal increments so that all x-values can be plotted by successive addition along the X-axis.

The data given in Tables I, II and III are for pressure angles of 14½, 20 and 30 deg, since the majority of gears and splines fall in one of these three groups. Adjustments for pressure angles other than these can be made by finding a point on the desired involute at which the pressure angle is 14½, 20 or 30 deg. This point can then be considered as the pitch point and its radius taken as the pitch radius for purposes of calculation and layout. Because of the popularity of the three pressure angles chosen, however, such adjustments will not often be necessary.

In Table I are given constants for points on the involute above the pitch circle. For these calculations, the plus signs preceding the term $\cos\phi$ in the brackets of Eqs (A1) and (B1) are used. Table II gives the constants with which plot points on the involute below the pitch circle can be readily calculated. Table III gives values of C_A and C_B for which the respective involute curves intersect their base circles.

For gears with 50 or more teeth, the values given in the upper part of Table I will be most useful. For 30 to 50 teeth, the values given midway in Table I will give the best results. The values in the lower part of Table I will be more suitable for pinions and splines. The data in the first column are used in every problem, whereas, only one of the other columns is used for a specific gear as determined by its pressure angle.

The last three columns of Table II are terminated at different points because the involute curve does not extend to the next step. In Table III are given the exact values of C_A and C_B at which the involute curves intersect their base circles. The values in Table III were calculated by evaluating the brackets in the following equations:

$$x = r\,[\cos\phi \ \text{vers}\ (\tan\phi)] \qquad \text{(A2)}$$

$$y = r\,[\sin\phi - \cos\phi \sin\ (\tan\phi)] \qquad \text{(B2)}$$

Equations (A2) and (B2) are obtained by substituting θ equals tan ϕ in Eqs (A1) and (B1) with the minus signs in effect. Radian measure was used for θ, that is, the number of radians in θ equaled the tangent of the pressure angle.

The procedure used when plotting an involute gear tooth with the tabular data given is indicated in the following example.

Table II—Involute Curve Constants for Plotting Below Pitch Point

$C_A = x/r$	$C_B = y/r$		
	ϕ = 14½ deg	ϕ = 20 deg	ϕ = 30 deg
0.002000	0.000008	0.000006	0.000005
0.004000	0.000033	0.000024	0.000016
0.006000	0.000074	0.000054	0.000036
0.008000	0.000134	0.000096	0.000065
0.010000	0.000212	0.000150	0.000101
0.012000	0.000309	0.000218	0.000146
0.014000	0.000426	0.000302	0.000198
0.016000	0.000565	0.000392	0.000261
0.018000	0.000726	0.000500	0.000331
0.020000	0.000912	0.000621	0.000410
0.030000	0.002306	0.001451	0.000935
0.040000	.....	0.002696	0.001686
0.050000	.....	0.004457	0.002675
0.060000	.....	0.006977	0.003917
0.080000	.....	.....	0.007231
0.100000	.....	.....	0.011828
0.120000	.....	.....	0.018081
0.140000	.....	.....	0.027087

Table III—Involute Curve Constants for Base Circle Intersection

$C_A = x/r$	$C_B = y/r$		
	ϕ = 14½ deg	ϕ = 20 deg	ϕ = 30 deg
0.032197	0.002782	.....	.....
0.061559	.....	0.007502	.....
0.140372	.....	.....	0.027319

Table IV—Coordinates of Tooth Profile for an 18 Tooth, 3 Diametral Pitch, 30 Degree Pressure Angle Gear

	C_A	$x = rC_A = 3C_A$, in.	C_B	$y = rC_B = 3C_B$, in
Points above Pitch Line	From Table I		From Table I	
	0.020000	0.060000	0.000391	0.001173
	0.040000	0.120000	0.001535	0.004605
	0.060000	0.180000	0.003393	0.010179
	0.080000	0.240000	0.005936	0.017808
	0.100000	0.300000	0.009141	0.027423
	0.120000	0.360000	0.012990	0.038970
Points below Pitch Line	From Table II		From Table II	
	0.020000	0.060000	0.000410	0.001230
	0.040000	0.120000	0.001686	0.005058
	0.060000	0.180000	0.003917	0.011751
	0.080000	0.240000	0.007231	0.021693
	0.100000	0.300000	0.011828	0.035484
	0.120000	0.360000	0.018081	0.054243
	0.140000	0.420000	0.027087	0.081261
Base Circle Intersection	From Table III		From Table III	
	0.140372	0.421116	0.027319	0.081957

EXAMPLE: Plot the profile of an involute tooth for a gear of 18 teeth, 3 diametral pitch, and 30 deg. pressure angle.

SOLUTION: From the conventional gear formula

$$r = \frac{18}{3} \times \frac{1}{2} = 3 \text{ in.}$$

This value of r is multiplied by values of C_A and C_B to obtain values of x and y, respectively, as indicated in Table IV. The coordinates x and y are then plotted as shown in Fig. 2 to obtain the tooth profile. For clarity of presentation the plot in Fig. 2 is shown enlarged.

Applying D-C Synchros

Accuracy, reliability and low cost, plus unique operating characteristics, make d-c synchros an excellent solution to many control problems. Here are six different ways to apply them for indication and control of light and heavy machinery. Differential wound receivers also have applications as regulators for valve or switch operation.

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THE LARGEST SINGLE USE of d-c (and a-c) synchros is for the remote indication of a mechanical motion. This motion may be applied to the transmitter in many ways. The usual method is the direct connection of a transmitter to a source of motion—for instance, the pointer shaft of a platform scale. The position of this pointer can then be shown at one or several other locations simultaneously.

A typical indicator application is shown in Fig. 1. Here, variations in water level are transmitted by a float to the sprocket of a geared transmitter, which in turn, transmits this motion through electrical connections to a receiver indicator at one or more remote places.

A slightly more complex system, ideally adapted to the d-c positioner, is that of a screw-down indicator for steel mill control, Fig. 2. Here the distance between rolls must be indicated accurately on a large dial, readily visible from a distance.

The problem of obtaining accuracy to the nearest 0.001 in. over a wide-operating range is solved with proper gearing. Because the sweep hand covered 0.1 in. per revolution, the dial was divided into 100 parts, each part representing 3.6 deg. To be accurate to the nearest division, the accuracy at the pointer must be at least ± 1 deg. The receiving synchro used had an error band ± 2 deg. The torque required to operate the gears introduced an additional error of ± 1 deg. The backlash of the gear train at the receiver was assumed to be ± 0.5 deg. Thus the receiver error was increased to ± 3.5 degrees.

To obtain the required accuracy, the gear ratio between the receiver and sweep pointer had to be at least 3.5:1; thus, the receiver travels 3.5 revolutions for each revolution of the sweep pointer. The gear ratio between the transmitter and the take-off shaft of the mill were selected to agree with the gear ratio between the receiver and the sweep pointer and the scale on the indicator dial.

A differential type wound rotor receiver is normally chosen wherever response to two different functions is desired. In a rolling mill, wear on rolls or a change in roll diameters after regrinding, require frequent setting of the pointer to zero. Since the large dial was inaccessible, a mechanical reset was discarded in favor of a hand-operated indexing transmitter, which furnished a separate excitation for the rotor vector field. Thus, the zero point can be readjusted by the mill operator whenever the rolls are brought together.

These two examples merely suggest a few of many indication applications. In addition, units can be built up for indicating and controlling complex functions, as will be shown.

Typical torque (control) applications of synchros are the remote operation of governors on prime movers, valve operation, gear changing, and rheostat operation.

One of the simplest types of remote control systems, with four rheostats controlling the fields of four generator exciters for an oil well drilling barge, uses d-c positioners. A number of special requirements made it impractical to locate the rheostats at the drilling barge. Therefore, small hand-operated transmitters were placed in explosion proof enclosures mounted at the barge. The operator could then control the output of the generators, which were on another barge, far enough away from the drilling operations so that explosion proof equipment was not required. These generators supplied a variable voltage to several motors, thus controlling their speed as desired.

Since direct current is the normal power supply for transportation equipment, both rail and marine, many helpful applications of d-c synchros are possible. The most common of these in marine work is that of remote propulsion control. A typical pilot house control stand can be visualized and corresponding engine room control stand is shown in Fig. 3. The transmitter, which is located in the pilot house stand, positions the receiver shown in the left foreground of the engine room control stand. This receiver operates two devices through gears, the generator field rheostat at rear center, and another transmitter at right foreground. This latter transmitter controls a receiver geared to the engine governor control shaft. The sequence of operation of these two controls is such that smooth propulsion control is achieved from engine idling speed (minimum generator excitation) to full engine speed (full generator output). A variation of this same system has been successful on diesel-electric traction drives.

Another common marine and power house application of d-c synchros has been in engine-order-telegraph or "repeat back" systems.

Each unit consists of a receiver and a transmitter connected in tandem or through gearing, and a contact-making mechanism. In this system, the supervisor can order a change in the operating condition of a piece of equipment, such as a turbine, by turning the

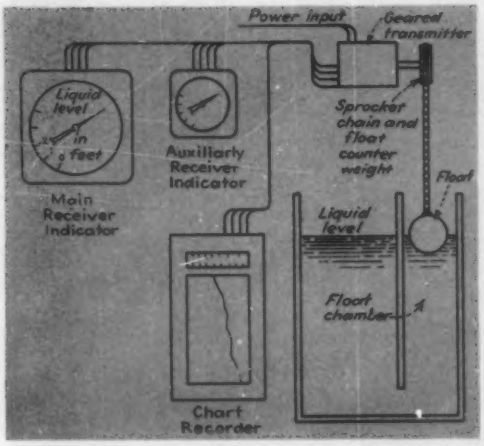


Fig. 1—Correct wiring, a dependable source of voltage, a float well adequate to damp turbulence in the liquid, and a dial comprise an accurate and effective liquid level indicator system.

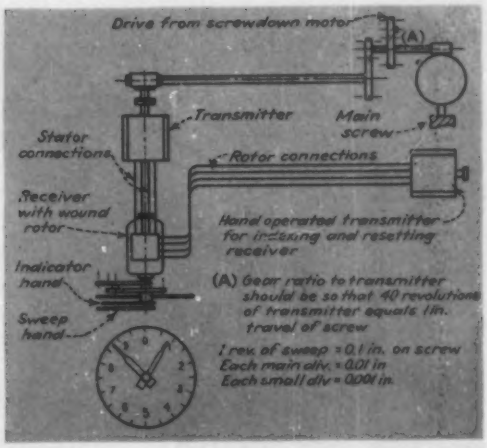

Drive from screwdown motor
(A)
Transmitter
Main screw
Stator connections
Rotor connections
Receiver with wound rotor
Hand operated transmitter for indexing and resetting receiver
Indicator hand
(A) Gear ratio to transmitter should be so that 40 revolutions of transmitter equals 1in. travel of screw
Sweep hand
1 rev. of sweep = 0.1 in. on screw
Each main div. = 0.01 in
Each small div = 0.001 in.

Fig 2—Screw down indicator for steel mill rolls. Differential type wound rotor receiver enables the operator to remotely reset the indicator pointer to zero whenever roll diameters wear.

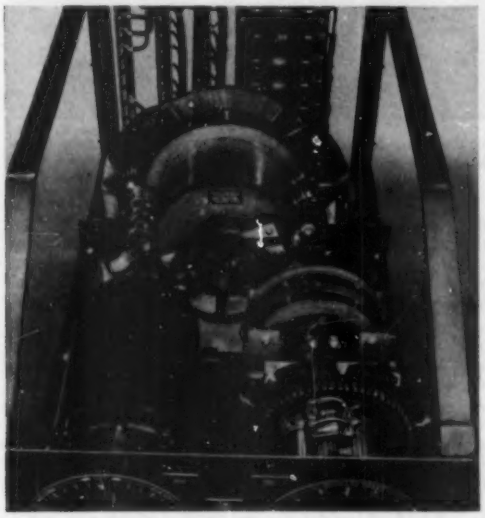


Fig. 3—Engine room control stand for a 1,500 hp tugboat. Receiver (left) operates both generator field rheostat and transmitter (right), whose signal positions the engine governor.

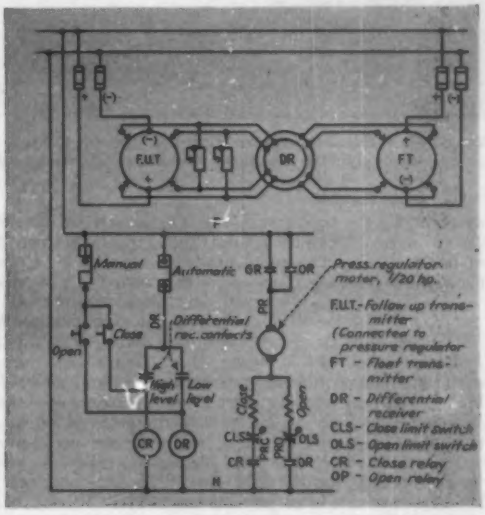


Fig. 4—This automatic float control system uses two transmitters to actuate one receiver One transmitter initiates the valve action required, the other "follows up" and terminates the action.

knob of the dual indicator. Sounding of an alarm notifies the operator that a change order has been made, and the receiver pointer on the operator's stand now indicates the new order. The operator then turns the knob on his stand so that his transmitter pointer agrees with the new order. The bells or lights are automatically disconnected when this is done.

One of the many ways in which a differential type of d-c synchro may be used as a regulator is shown in Fig. 4. The purpose of this control is to maintain the elevation of the water in the forebay of a hydraulic turbine plant within certain pre-set limits. A transmitter *FT* is mechanically connected to a float located in the forebay and electrically connected to the stator of a differential type receiver *DR*. Any change in water level will result in rotation of this transmitter and equal rotation of the receiver rotor. Connected to the shaft of the receiver are the open and close relays. Depending on the direction of receiver rotation, one of the contacts will close relay *OR* or *CR*, energizing the split field motor which drives the pressure regulator valve of the hydraulic turbine governor, opening or closing it as required.

This valve is geared to the follow-up transmitter *FUT*, which, in turn, is electrically connected to the rotor of the differential receiver. The receiver rotor then turns in a direction opposite to that of the original signal, opening the controls just closed (or vice versa)

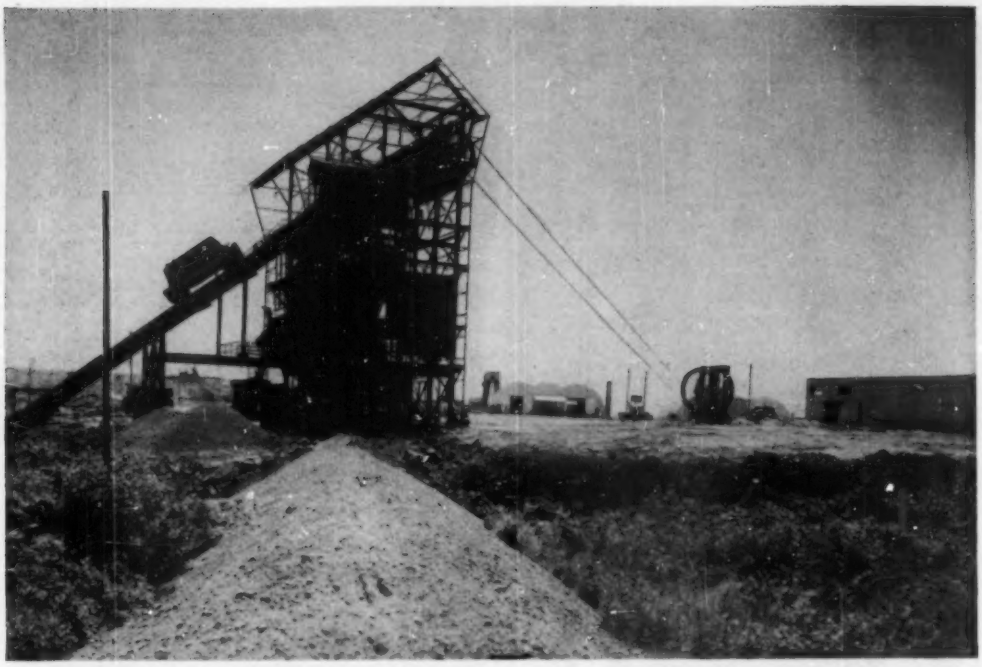


Fig. 5—M. A. Hanna Co. mine in Minnesota. The two 50,000 lb hoist cars are loaded, raised to the control tower, dumped, and returned to the pit in less than 1 min. Building at right houses the hoist brake and its 1,300 hp a-c drive and control

and bringing the system into balance. Compensation is provided for the play in the contact mechanism to prevent hunting and recycling.

Hoist Control

The versatility of d-c synchros in complex control jobs is shown in a recent skip hoist control modernization, Fig. 5. Here the operator must have complete control of the car acceleration, speed, direction of travel, and braking at all times. The ideal place for the operator was the hoist tower, but there seemed to be no practical way of providing braking and motor control through levers or hydraulic means from this position. The solution was made possible through the use of d-c synchros.

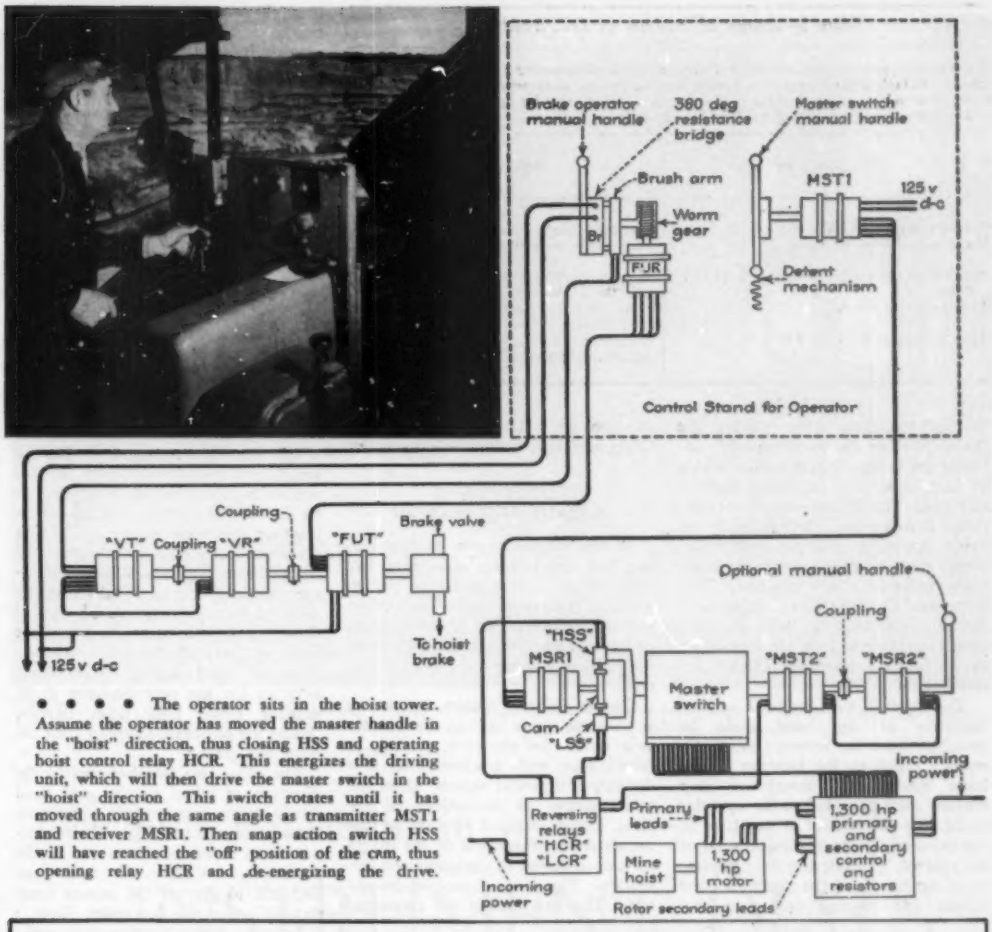
The circuit of the final control is shown on page 107. It is composed of three basic units, the operator's stand containing both remote control and braking transmitters, the brake valve operating unit in the hoist shed, and the receiver operated master motor control, also in the hoist shed.

Movement of the master switch handle located in the remote operator's stand moves transmitter *MST*1 through an angle proportional to the angular movement of the operating handle. Receiver *MSR*1, located near the master switch, then rotates through the same angle as the transmitter. Connected to this receiver shaft, which is concentric with the master switch shaft, is an operating cam. Movement of this cam in either direction will actuate the "lower" or the "hoist" snap-action switches (*LSS* or *HSS*). These switches are mounted on the shaft of the master switch and are, therefore, concentric to the cam on the receiver shaft. To illustrate how this device functions, a schematic arrangement has been prepared.

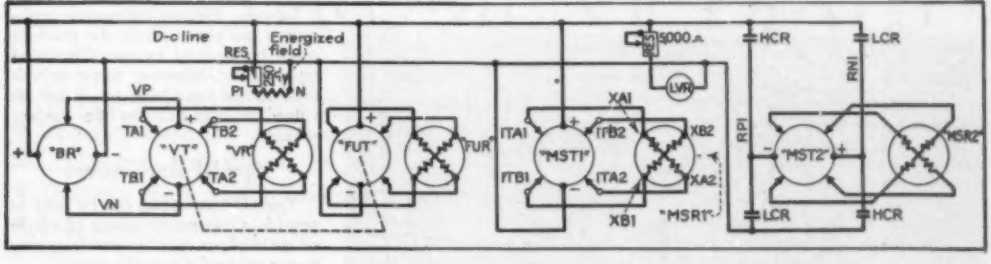
The driving unit, whose job is to position the master switch accurate to within a few degrees on each of fifteen positions without under- or over-travel, is composed of transmitter, *MST*2, and receiver *MSR*2. This transmitter is both mechanically and electrically connected to the receiver. The receiver is coupled to the transmitter with approximately a 45 degree electrical angle of displacement so that as soon as voltage is applied to the transmitter, the receiver starts to rotate in the direction that would neutralize the displacement angle. However, the rotor of the receiver and the transmitter are mechanically coupled so the transmitter also rotates. This combination transmitter-receiver runs like a motor as long as power is supplied. Rotation direction is determined by polarity of the voltage applied to the transmitter by control relays *LCH* and *LCR*. Because receiver *MSR*2 has a permanent magnet rotor, it acts as a generator when the power is interrupted, braking the unit to an immediate stop and eliminating the need for an electrical brake. This latter function is important, since it is the final link in a series of operations that must all take place accurately and quickly.

A typical sequence begins when the operator moves the transmitter handle three notches forward and ends as the master switch moves continuously ahead exactly three positions and comes to a stop. Regardless of how fast the operator moves the control handle forward, the positioning speed of the control never exceeds the safe limit determined by the design characteristics of the driving unit. Because the electrical angle of displacement in the driving unit combination is approximately 45 degrees, both the starting and stopping acceleration of the driving unit is alike. No damage will result if the master switch becomes jammed.

The operator's brake handle located in the remote operator's stand is connected to resistance bridge *BR*. Rota-



● ● ● ● The operator sits in the hoist tower. Assume the operator has moved the master handle in the "hoist" direction, thus closing HSS and operating hoist control relay HCR. This energizes the driving unit, which will then drive the master switch in the "hoist" direction. This switch rotates until it has moved through the same angle as transmitter MST1 and receiver MSR1. Then snap action switch HSS will have reached the "off" position of the cam, thus opening relay HCR and de-energizing the drive.



tion of this unit produces voltage on the transmitter *VT*, a part of the brake valve driving unit located at the hoist drum. This voltage will be proportional to the angular movement of the operator's handle.

The driving unit, transmitter *VT* and receiver *CR*, operate as does the master switch driving unit, except that the magnitude and polarity of the applied voltage is determined by bridge *BR*, and that the electrical angle of displacement between *VT* and *VR* is less than 45 degrees. This latter feature provides quick acceleration upon opening the hydraulic brake valve, and a somewhat slower deceleration for brake closing, to prevent jamming the valve.

The follow-up receiver *FUR* in the operator's stand is electrically connected to and is controlled by transmitter *FUT* in the brake valve operating unit. This receiver rotates the brush assembly on the resistance bridge *BR* through proper gearing.

To illustrate a complete cycle of operation, assume the operator moves the brake control handle forward quickly. The driving unit rotates at full speed,

Table I—Range of Ratings of D-C Synchros

These ranges cover the characteristics of standard stock units operating on 125 v d-c. Modifications available include special or double shaft extensions, waterproof and dustproof cases, special low voltage units, rectifier power supply, series resistor for operating on 250 v d-c, and energized vernier field and fixed field rotors for some receivers.

Transmitters	Receivers
Output rating: 5 to 200 watts Max. input: 30 to 500 watts	Wattage ratings: 5 to 200 watt Max. static pull-out torque: 0.312 to 130 lb-in.
Max torque required for rotation: 0.25 to 1.5 lb-in. Accuracy: 1 to 2.5 deg	Torque Gradient 0-45° per deg deflection: 0.008 to 2.0 lb-in. Torque at max. operating speed: 0.312 lb-in. at 550 rpm to 10 lb-in. at 120 rpm Accuracy: 0.8 to 2.5 deg
Approx. weight: 0.75 to 20 lb	Approx. weight: 2 to 85 lb

driving the brake valve toward the closed position and simultaneously rotating the follow-up transmitter, which in turn causes the follow-up receiver to rotate. The follow-up receiver continues to rotate until the voltage on the valve operating unit transmitter becomes zero and rotation stops with the brake valve in a new position. This the action of the brake corresponds to that in an automobile, with stopping power applied exactly in proportion to the forward movement of the control handle.

The control was designed so that operation of the hoist could be switched from the remote control operator's stand to the location of the hoist mechanism. Emergency stop buttons were provided so the operator could stop the control at any time in the event of failure or misoperation of the control. Considering the complexity of the functions, the control is quite simple and requires only occasional maintenance. Loading speed and safety have both been greatly increased.

Synchronizing Angular Displacement

In the design of a new 30 foot boring mill, the problem of keeping two independent cutting tool feed motors within a few revolutions of each other, throughout the period of acceleration and run on any given cutting operation, was solved by using a d-c synchro system.

One of the two motors was set up as a master motor and the other motor as a slave. An electronic control, in combination with synchros used in a dynamic differential system, keeps the total number of revolutions of the slave motor identical to that of the master motor, regardless of the length of time required to complete one operation. Fig. 6 is a layout of the system. The two motors are connected through gear reducers to two similar transmitters. Since the application involved dynamic torque, the gear reducer ratio was detemined by the speed-torque characteristics of the receiver. At the same time speed had to be kept low enough to insure low maintenance on the transmitters. The two receivers, which are electrically connected to the transmitters, operate a mechanical differential whose output rotation is zero when the two motor speeds are identical, since the receivers rotate in opposite directions.

Any time the relative speed of the two motors varies, the take-off gear of differential *A* will begin to rotate, and in proportion to this difference. This take-off gear drives one input to differential *B* through gearing. Because of the high gear ratio in the gear motor drive, the take-off shaft of differential *B* will in effect be locked, so that the second input shaft will turn in proportion to the output of differential *A*. Its direction of rotation will depend on whether the slave motor is turning slower or faster than the master. This shaft drives a potentiometer which supervises the control signal fed to the slave motor electronic speed control device. This same shaft also supervises four cam-operated snap action switches. Two of these act as travel limit switches for the potentiometer shaft, shutting down both main motors, should the accumulated speed error become too great.

The other two switches control the direction of travel of the gear head motor, which operates only when main motors are not running. Their function is to supervise the return of the potentiometer shaft to the center position and to prevent the motors from starting unless this has taken place.

In some dynamic differential applications the two separate d-c receivers could be replaced by one differential type receiver. However, wherever both high accuracy and high speeds are involved, separate receivers offer the best solution.

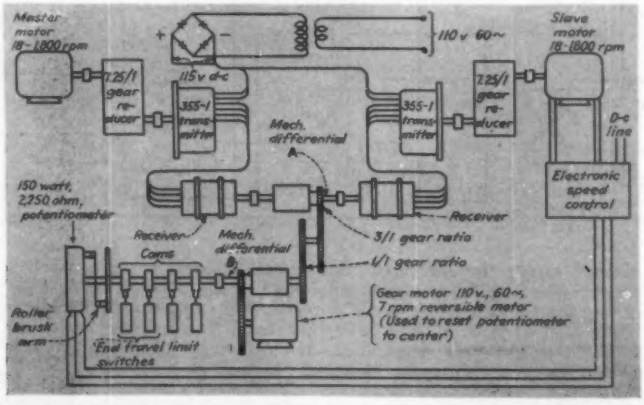
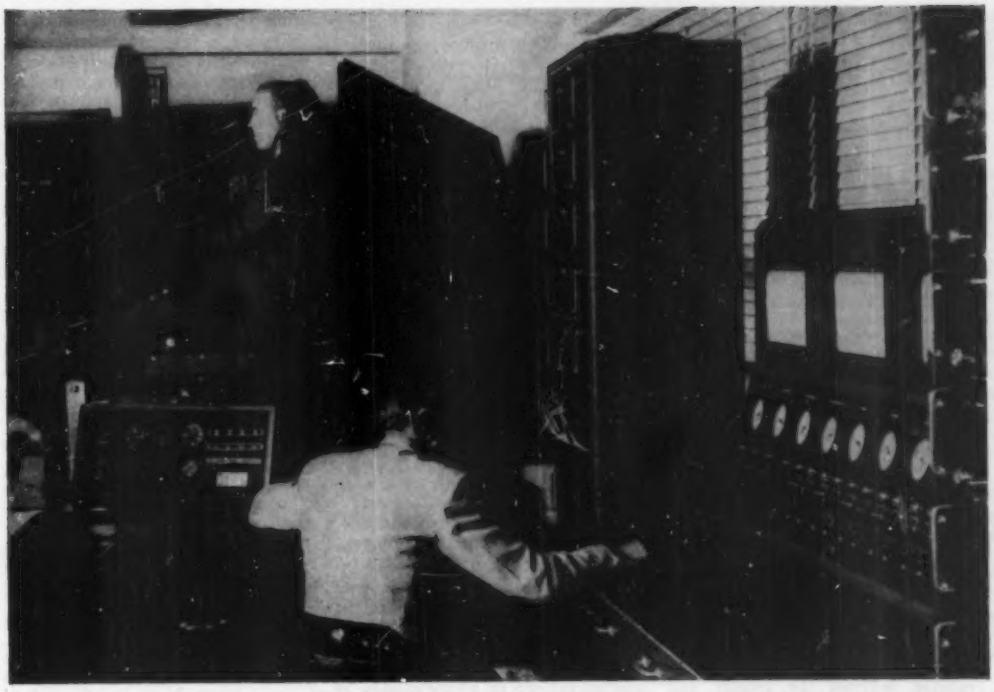


Fig. 6—This boring mill control will synchronize the total revolutions of two independent feed motors throughout a run. Control is arranged so that master and slave motors will not start until potentiometer arm is in center of resistance element.

Special Applications

Transmitters, alone, can be used to provide a convenient source of single or multi-phase variable low-frequency power source for special purposes.

Two-phase d-c receivers, actuated by independent signals of d-c voltage and current can be used as power indicating or control devices. In typical applications receivers have been used as automatic current limiting devices and accelerating relays in d-c motor control circuits, or as wattmeter elements supplying torque for operation of mechanical and hydraulic regulating equipment for power systems.



TESTING RELATIVE OPERATOR REACTION TIME in the reading of a variety of instrument dial designs at the Areo-Medical Laboratory of the Wright-Patterson Air Force Base, Dayton, Ohio. Compiled results will aid instrument designers.

Obtaining Readability in . . .

INSTRUMENT DIALS

- Types and causes of dial reading errors.
- Recommendations on scale numbering, zero point location, and changes in scale values.
- Dials for check reading and multi-revolution instruments.
- Dial visibility and lighting.

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Aero Medical Laboratory,
Wright-Patterson Air Force Base

THE TREND TOWARD INSTRUMENTATION, particularly in the fields of remote-controlled equipment and precision measurement, makes the design of instrument dials a significant element of the designer's job.

Accurate quantative indication by an instrument does not necessarily insure accurate reader response. To be completely useful, an instrument dial must be easy to read and difficult to misinterpret. The very effort to get utmost precision often results in an instrument that invites reading errors.

Traditionally, instrument dial design has been entirely a matter of common sense, but recently the Aeromedical Laboratory of the Wright-Patterson Air Force Base has been doing research to develop a scientific basis for instrument dial design. Studies on the psychological considerations of dial reading have resulted in a better understanding of how errors occur in the reading of instruments, and how these errors can be minimized by proper design.

Comprehension vs Precision Errors

Comprehension errors are caused by the gross misreading of an instrument. Examples are: a pilot misreading his altimeter by 1,000 ft, an artillery man setting his sights 100 mils too high, or a micrometer misread by a complete turn of the barrel. These errors are normally large, and usually bear a simple relationship to the major divi-

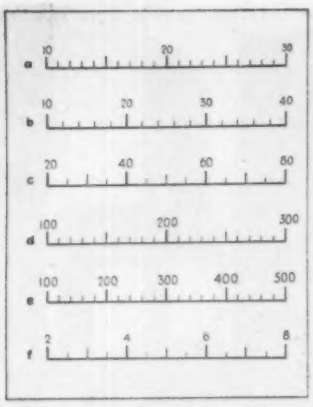


Fig. 1—Typical scale using common and desirable increments of: (a) one unit, (b) two units, (c) five units, (d) ten units, (e) twenty units, (f) half units.

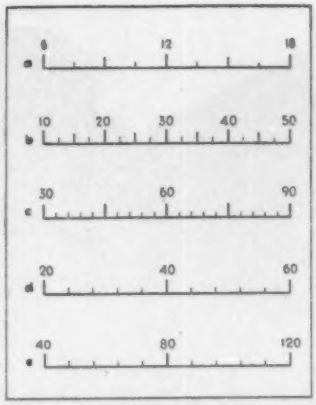


Fig. 2—Some uncommon and difficult increments: (a) one and one-half; (b) two and one-half; (c) three; (d) four; (e) eight units.

sions on a scale. Such errors can be dangerous, expensive, or merely embarrassing in their consequences.

More common, but less serious, are what may be called precision errors. These result from inaccuracy in interpolating between scale marks or from parallax between the pointer and scale. Errors of this type are of necessity small in magnitude, usually less than the smallest division on the scale. Although they cannot be ignored such errors are far less of a hazard than the comprehensive type.

Check Reading

In a somewhat different category are errors or reading difficulties which are not strictly quantitive in nature, but relate rather to the detection and understanding of changes in the indication. Some instruments, for example, are ineffective in catching the attendant's attention in case of a sudden fall or rise from a desired stable value. Or after the attendant has detected the change in indication he may misjudge the direction, and therefore take action which is exactly opposed to that demanded by the emergency. This last category is classified as a difficulty in check reading, as opposed to difficulties in quantitative reading.

All design considerations must be based on the ultimate purpose of the instrument reader. Even with the best set of general rules to guide him the engineer must bear in mind the manner in which his instrument will be used.

Subdividing the Scale

Usually there will be a certain range of values which the scale must cover, and often the space into which this scale must be fitted is limited by the particular application. With this information before him the designer must then choose the values for the scale graduations.

Research has shown that the reader is least likely to be confused if the smallest division on a scale is unity, as shown in Fig. 1(a), or some decimal multiple of unity, such as 0.1, 10, Fig. 1(d), 100, or 1,000. On such a scale the half-way mark, in the fives position, should be longer than the units but shorter than the tens marks, giving major, minor and intermediate graduations.

Such a scale divided into units (or decimal multiples of unity) is not always the most practical. Because of the range of values to be covered, and the physical limitation on the length of the scale, divisions of unity may be too close together to be legible, or they may be so far apart that the available scale length is not being used efficiently. In such a case the smallest divisions may be given values of 2 or 5, as in Fig. 1(e) or Fig. 1(f). Still other subdivisions are sometimes used with values of 1.5, 2.5, 3, 4 or 8, as shown in Figs. 2(a), (b), (c), (d) and (e), but these should generally be avoided to prevent confusing the reader. There appear to be two reasons why these divisions other than 1, 2, or 5 are undesirable: (a) they are less familiar to the average dial reader; and (b) interpolation into simple decimal fractions is generally more difficult.

It should be pointed out that there are numerous exceptions to the above rules, particularly on scales based on English weights and measures. Measuring tapes and rules are normally graduated in feet, inches, half-inches, quarter-inches, etc. Similarly, scales of weight are sub-divided into pounds, ounces, half-ounces, and quarter ounces. Only familiarity with these scales makes their use practical.

Numbering the Scale

Numbers should be placed at as many as possible of the major divisions along the scale. Research has shown that large erorrs occur if the numbers are far apart on the scale. In reading clocks with numerals only at 3, 6, 9, and 12, for example, errors of one hour in the readings are common. All major graduations should be numbered if space will permit. Preferably the numbered graduations, like the smallest increments, should increase by steps of one, two, five, or decimal multiples, shown in Fig. 1, rather than other possible steps such as shown in Fig. 2. The size of the numerals must be chosen to suit the probable reading distance, the lighting conditions, and the contrast between the numbers and their background.

Location of Zero Point

Experimental studies indicate that in most cases location of the zero point on a scale is not particularly important, unless the reader has firmly fixed habits for reading that particular function. On circular dials the zero may be located anywhere on the circle. But to change a clock dial for example, so that zero for the minute hand is at the bottom instead of the top, will trip up many readers. For less familiar instruments the designer can choose the location of his zero point.

Unless the pointer makes more than

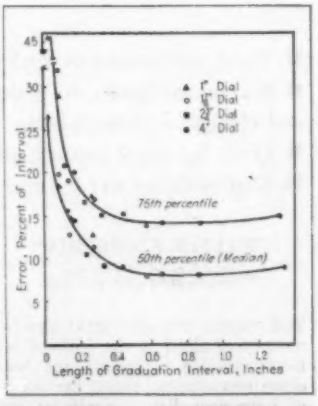


Fig. 3—Relative accuracy of instrument interpolation as a function of the space between graduation marks.

one revolution (as on a clock) there should be a distinct gap between the end of the scale and the zero point.

Dial Size and Separation of Scale Marks

The overall size of the dial or scale is often limited by the application. This is particularly true of aircraft instrument, few of which exceed a standard diameter of 2.75 inches. The major effect of dial size on instrument readability is in the determination of scale length, and thereby the space between graduation marks. The accuracy of readings, particularly the accuracy of interpolation, is dependent upon this space as shown in Fig. 3. For a reading distance of 30 inches, the accuracy of reading relative to the interval falls off rapidly as the space between graduation marks is reduced below about 0.25 inch. On the other hand there is no gain in interpolation accuracy from an increase in dial size that places the smallest graduations more than 0.5 inch apart. Increase in dial size, can, however, be used as a means of increasing accuracy if the scale is further sub-divided.

How far can the sub-dividing of the scale be carried in order to obtain the utmost in reading precision from a fixed length of scale? This question is partially answered from Fig. 4, plotted from the same data as Fig. 3. The difference is that Fig. 4 shows the absolute error of reading, and Fig. 3 the relative error (in percent of the interval). It is clear that the absolute error continues to diminish down to the smallest interval used, (0.032 inch interval at 30 inches reading distance).

Although the data of Fig. 4 show that maximum precision is possible with a very finely divided scale, this will be true only under optimal conditions of good lighting and an abundance of time for making and double-checking the reading. A scale with a large number of closely spaced graduations will require more time for reading and will produce a greater number of the large comprehension type errors. In dim light, and for people with poor visual acuity, closely spaced divisions will not be visible as separate lines, and are worse than useless.

Although the optimum space between scale marks will vary for different applications, a number of general rules can be stated: (a) the scale should not be divided into smaller values than will be used by the reader: (b) the scale divisions should not be smaller in value than the expected accuracy variation of the instrument mechanism; and (c) it must be remembered that rather open scales, with generous spacing between marks, are most favorable for rapid reading, relative accuracy of interpolation, and freedom from large reading errors.

Change in Scale Values

Instruments on which the scale increases in a logarithmic rather than a linear or arithmetic progression present an especially difficult scale design problem. The slide rule is such an instrument. It is usually necessary, in such a case, to use different graduation values in different parts of the range. The reader is particularly likely to read the graduations incorrectly in passing from one region of the scale to another. Such shifts in graduation values should be avoided if at all possible. Where they cannot be avoided the change should be made obvious to the reader by differences in dimensions, color, or shape of the marks.

Designing for Ease of Check Reading

For many instruments the quantitative indication is of only incidental value. The primary purpose is warning of the operator in case of malfunction and providing him with enough information so that the proper decision can be made and action taken. Instruments of this nature are most of the so-called engine instruments in aircraft, the ammeter, temperature, and oil pressure gages in automobiles, and a large variety of other voltage, frequency, or pressure indicators. The best design for quantitative reading is not likely to be the best for check reading.

Where check reading is a major consideration the instruments can often be arranged so that a whole group of instruments can be checked almost in a single glance. One such arrangement, being adapted to multi-engine aircraft, is shown in Fig. 5. In this rectangular arrangement vertical columns represent engines and horizontal rows functions, such as engine rpm, fuel pressure, and tail pipe temperature. When all indications are correct the 16 pointers form four lines. The deviation of any one pointer, causing a break in one of the lines, can be detected and reacted to in about 0.75 seconds. Any such patterning of pointers to give a simple configuration should benefit check reading.

Even for single instruments the design can have a considerable effect

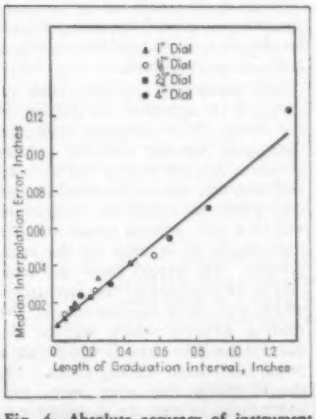


Fig. 4—Absolute accuracy of instrument interpolation as a function of the space between graduation marks.

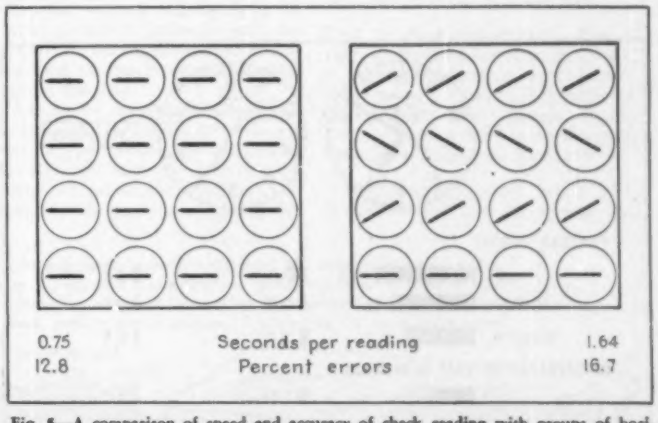


Fig. 5—A comparison of speed and accuracy of check reading with groups of horizontally aligned and mixed alignment instruments. Where quantitative indication can be dispensed with entirely, mere warning lights are sometimes used.

on ease of check reading. An instrument on which the pointer moves is significantly easier to check than one on which the scale moves behind a fixed pointer. A rotating pointer is normally easier to check than one moving along a linear scale. For aiding check reading the pointer should be made relatively broad and long, and should stand out clearly against the background.

Multi-Revolution Instruments

Many instruments cover such a wide range that they must use more than one revolution to give accuracy. The clock, altimeter, and micrometer are common examples. These instruments are subject to large errors, often representing a complete revolution. One solution to this problem is the direct reading counter, which is coming into more general use.

A comparison in terms of speed and accuracy of quantitative readings of three possible altitude indications is shown in Fig. 6. The instrument on the left is a conventional three-pointer altimeter, and the one on the right a direct reading counter.

It would seem from Fig. 6 and similar data from other experiments that if the sole purpose is to give the reader the right number a direct reading counter offers the best solution. On the other hand, if the instrument is also to be used in a check reading manner, as a qualitative indicator of changes taking place, deviations on a counter are more difficult to use than movements of a pointer.

Control Motion in Relation to Instrument Changes

Many instruments are directly influenced or adjusted by rotary motion of control knobs. It is highly desirable that in such control-indicator combinations the operator obtain the expected change on his first attempt.

The following rules, covering the most common situations, appear to be well founded:

a. Knobs should rotate clockwise for increase, counterclockwise for decrease.

b. Levers should move forward, upward, or to the right for increase, the opposite for decrease.

c. For rotational instruments the knob should rotate about an axis parallel to that of the dial or pointer. Clockwise motion of the knob should produce clockwise rotation of the moving element on the instrument.

d. For instruments with linear motion (or a rotational axis parallel to the pointer tip) the knob should rotate about an axis perpendicular to the line or arc along which the pointer or scale moves.

e. Where two or more knob-indicator combinations are operated by the same person in succession consistency of motion relationships is particularly important.

Direction of Scale Increase

It is conventional to design linear scales so that the values increase from left to right or from bottom to top. On circular scales the values normally increase in a clockwise direction. The reader is accustomed to these conventions and will be confused when these directions of increase are reversed.

Visibility of Markings

Good visibility involves four interrelated variables: lighting, distance of viewing, size of markings, and the contrast between markings and background. Most of the experimental work has been in the field of lighting. The problem is essentially one of obtaining good visibility without glare, or without disturbing the dark adaptation of the eye. The three main types of instrument lighting are as follows:

1. Flood lighting. Fixtures in the cockpit or room illuminate the instruments. This gives good lighting if the fixtures are properly placed, wherein lies the problem. They should be above the line of sight so all reflections will be downward. The lamps should be shielded to prevent the illumination from reaching the eyes of the observer directly.

2. Indirect light. Light around the rim of the instruments illuminates pointer and markings, the light striking the instrument at a very oblique angle. Typically this gives greatest brightness at the rim, with rather poor illumination of the pointers. Mechanical problems arise where instruments are very close together as in aircraft. In automobiles where instrument panel space is less critical, indirect lighting can be made quite satisfactory.

3. Rear lighting. Lights behind the dial shine through translucent markings. Except for the difficulty of illuminating the pointer, which is usually an acrylic polymer such as Lucite or Plexiglass with light piped into it, this gives very good lighting. Disadvantages for aircraft use are the need for heavy plastic pointers, and the space required for the lights within or around the instrument case.

Where it is important to preserve dark adaptation of the observer's eyes, white markings on a black background are preferred. The white on black relationship reflects less total light into the observer's eyes and therefore permits more complete dark adaptation for vision outside the aircraft or auto.

If either the markings or the background are colored the colors should be chosen so as to give the maximum contrast in brightness.

An important principle, here restated, is to remember the purpose of the reader. The designer should be thoroughly familiar with the manner in which his instrument will be used and who will use it. He should know the system of which the instrument will be a part, and the nature of other instruments to be read by the same operator. He should know the accuracy to be expected of the mechanism which will drive the instrument, the reading accuracy which will be demanded, and the hazards which might result from large reading errors. He should realize that what seems easy and natural to him, the designer, may be completely confusing to the uninitiated operator.

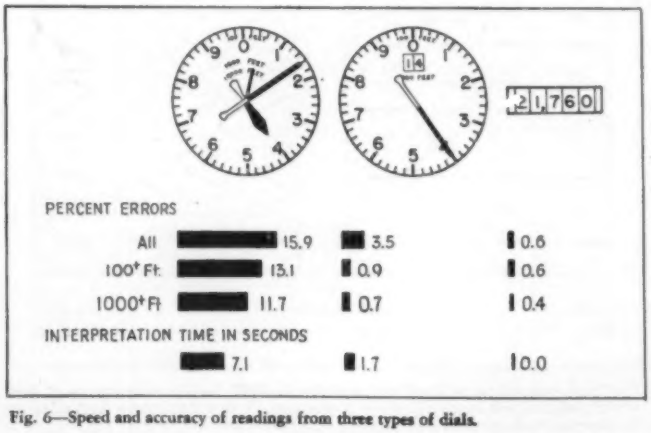


Fig. 6—Speed and accuracy of readings from three types of dials.

DESIGNING FOR
Projection Welding

HOW to use projection welding for sheet stock, forgings, curved surfaces, waterproof joints, wire, and fasteners. Shape, size, and shear strength of common types of projections. Basic rules for obtaining successful joints. From a forthcoming book to be published by the McGraw-Hill Book Company on resistance welding methods.

WALLACE A. STANLEY
Product Design Consultant,
Progressive Welder Company

PROJECTING WELDING, an extension of the use of spot welding, has perhaps the greatest application potential of any of the resistance welding processes. Although its application at present is more limited than spot welding, since it cannot yet be used on the lighter gage metals or when surface appearance is of paramount importance, its development is only in the initial stage.

In projection welding, a protrusion, embossment, tab, or button is formed at the designated weld location prior to placing the parts in the welder. This projection becomes a part of the path of the welding current. External pressure and current is applied by relatively large copper contacting surfaces—either in the form of flat electrodes or dies of greater surface area than the projection—so that several welds often can be made simultaneously. The copper dies require less frequent dressing than individual welding tips, and therefore have a longer production life and give more consistent weld size. Also, welds can be more closely spaced than for spot welding since the current will flow through the projections rather than shunt through adjacent metal sections, and will heat the weld.

The largest application for projection welding is in the welding of mild steel, stainless steel, most steel alloys, and coated steel such as terneplate, tinplate and galvanized steel; mild steel sheet, ranging in thickness from 18 gage to ¼ inch thickness is the most commonly used material. Many materials, however, cannot be successfully projection welded because the metal is not strong enough to support the projection under pressure while the welding current is flowing. The strength of the metal must be such as to insure complete rigidity of the projection until the proper plastic state is reached. This mechanical limitation can sometimes be overcome by the use of special welding techniques or by special projections although such exceptions are usually confined to laboratory work or low production applications in the shop.

Among the common metals difficult or impossible to projection weld are brass, copper, aluminum, magnesium and numerous other metals having the limitations previously mentioned. In special cases projection welding has been successfully applied to such combinations as steel to brass, steel to aluminum, and steel to bronze. But joining of such dissimilar metals by projection welding should be done only under the supervision of competent welding engineers who are thoroughly familiar with the special techniques required.

Also, very thin or very thick sections require critical considerations: (1) because of the low physical strength of the projection in the thin sheets, and (2) the difficulty of producing projections by dies in the thicker pieces.

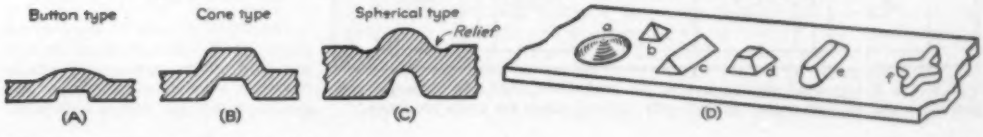
Common Types of Projections

There are three types of projections generally used in the making of projection welds: The button type, the cone type, and the spherical type.

THE BUTTON PROJECTION, Fig. 1 (*A*), derives its name from its appearance as a little button of convex surface at the point of welding. It is employed in flat sheets of thicknesses ranging from 24 gage or 0.025 in. minimum to 13 gage or 0.0937 in. maximum.

THE CONE PROJECTION, Fig. 1 (*B*), derives its name from its appearance as

Fig. 1—Standard projection (A) and other projection (B) and (C) commonly used on thin strip. The projections shown at (D) are used on forgings: a, spherical button; b, three or four sided pyramid; c, elongated pyramid to achieve a linear bond; d, truncated pyramid for heavy parts; e, truncated cone for linear weld or curved surfaces; f, cross type for extra heavy parts.



a flat topped cone. It is more rigid than the button type, and is used for projection welding of sheets from 12 gage or 0.1093 in. thick to 5 gage or 0.218 in. thick.

THE SPHERICAL PROJECTION, Fig. 1 (*C*), takes many different forms according to the intended use and is for projection welding heavy sections and forgings. Note the depression surrounding the spherical projection called the "relief" into which the metal from the projection can flow as it reaches plastic state. Without the relief the upset metal of the projection would have no place to go except between the faying surfaces, and thereby would separate the sheets.

Other types of projections have been designed to serve special functions. Such a group of varying types, sizes and shapes are shown in Fig. 1 (*D*). The fictitious strip shows different types of projections used successfully in industry in the projection welding of forgings.

A projection should theoretically be round or as close to it as possible, because the weld "grows" from the center outward. Actually, however, any conveniently made projection can be used whether oval, square, oblong, circular or curved. When two projections are used to join parts together, the complete "leveling" or equalization of the projections is ordinarily quite easily accomplished. When three or more projections are used to join two or more parts together, the problems of equal heights and simultaneous leveling presents themselves. The difference in the use of three or four projections may be compared to the difficulty in leveling a three legged as against a four legged stool. If three projections are used they will equalize themselves if the welding die alignment is reasonably close, but with four or more projections, there is a possibility of "rocking" due to one of the projections being of a slightly different height.

The problem of "in which piece should the projection be placed" must be decided by the physical laws of heat transfer. Generally speaking, when welding sheets of different thickness, the projections should be placed in the heavier of two as the greater mass of the thicker sheet requires a longer time to reach the welding temperature. On other than plain flat sheets this rule is not always necessary to follow.

For example, in Fig. 2 (*A*) it is of great importance whether or not the projection be formed in the thinner upper stamping because the lower part is hollow. Where the metal thickness at the intended weld spot is not more than three times that of the thinner part, it is usually better to put the projections in the thinner stamping, as illustrated. A flat copper electrode would be used on the top surface of the stamping while a chuck type stationary circular copper die would be used to prevent the lower part from slipping during welding.

If the ring projection were placed on the stamping as shown at the top of sketch (*B*) instead of in the solid bar, it would quickly reach welding temperature without a corresponding rise in the solid bar and a poor weld would result because the weld nugget penetration would be greater in the stamping than in the bar. On the other hand, if the ring projection were machined onto the end face of the bar instead of being formed on the stamping, it would localize the passage of welding current and bring both the bar and stamping to proper welding temperature simultaneously. The resulting weld, shown at (*C*) would be of sufficient penetration in each part.

Table I indicates the sizes and shear strength of projection welds as given by the Resistance Welder Manufacturers Association and the American Welding Society. The permissible spacing between the projection welds, the allowance for flanges, the allowance for overlap, the nugget diameter and projection sizes are all set out for given thicknesses and gages.

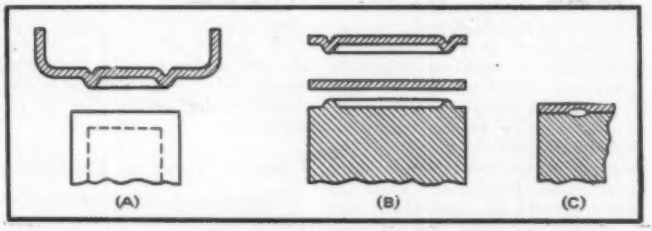


Fig. 2—On which part should the projection be placed? Generally on the heavier part, but not necessarily so. The projection should not be on the stamping (B), top.

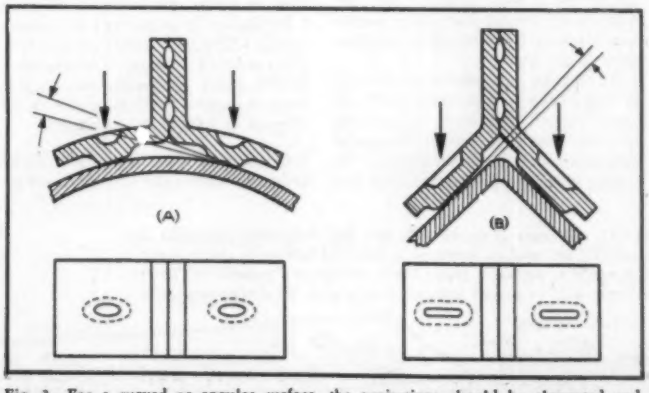


Fig. 3—For a curved or angular surface, the projections should be elongated and tapered so that the first contact progressively "grows" across the entire projection.

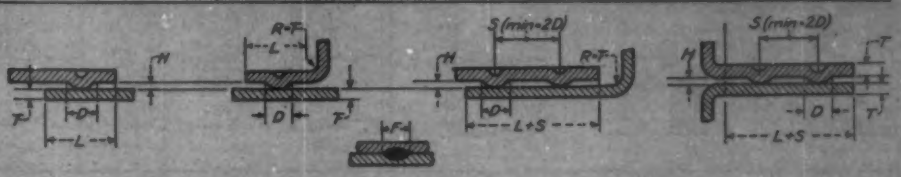
Projections on Curved Surfaces

A departure from the normal button type projection is not only desirable but often is imperative if the surface to which the part is projection welded is curved or in a different plane, as shown in Fig. 3. In specifying the proper type projection for curved or other than flat surfaces, as at (A), the projections must be elongated in proportion to the angle of the plane of the surface to the die movement. A progressively worse condition is shown at (B). The reason for this is the "skidding action" of the projection on the curved surface and the actual development of contact by the projections as the moving part approaches intimate contact with the opposite part.

Circular Ring Projections

The use of circular or annular ring projections has been successful in parts requiring either waterproof attachments or a larger weld area to give maximum strength within a given di-

Table 1 — Size and Shear Strengths of Projections in Low Carbon and Stainless Steel[1]



Nominal Thickness "T" of Thinnest Outside Piece		Diameter of Projection "D", in.	Height of Projection "H", in.	Minimum Shear Strength (Single Projections Only) lb.			Minimum Diameter of the Weld Zone at Weld Interface "F", in.	Minimum Contacting Overlap "L", in.	Minimum Dia. of Electrode Face (d), in.
Inches	USS. Gage			Tensile Strength Below 70,000 psi lb.	Tensile Strength 70,000 to 150,000 psi lb.	Tensile Strength 150,000 psi and Above lb.			
0.010	32	0.055	0.015	130	180	250	0.112	1/8	1/8
0.012	30	0.055	0.015	170	220	330	0.112	1/8	1/8
0.014	29	0.055	0.015	200	280	380	0.112	1/8	1/8
0.016	28	0.067	0.017	240	330	450	0.112	5/32	5/32
0.021	25	0.067	0.017	320	440	600	0.140	5/32	5/32
0.025	24	0.081	0.020	450	600	820	0.140	3/16	3/16
0.031	22	0.094	0.022	635	850	1,100	0.169	7/32	3/16
0.034	21	0.094	0.022	790	1,000	1,300	0.169	7/32	3/16
0.044	19	0.119	0.028	920	1,300	2,000	0.169	9/32	1/4
0.050	18	0.119	0.028	1,350	1,700	2,400	0.225	9/32	5/16
0.062	16	0.156	0.035	1,950	2,250	3,400	0.225	5/16	5/16
0.070	15	0.156	0.035	2,300	2,800	4,200	0.281	5/16	3/8
0.078	14	0.187	0.041	2,700	3,200	4,800	0.281	7/16	5/8
0.094	13	0.218	0.048	3,450	4,000	6,100	0.281	1/2	7/16
0.109	12	0.250	0.054	4,150	5,000	7,000	0.338	5/8	1/2
0.125	11	0.281	0.060	4,800	5,700	8,000	0.338	11/16	9/16
0.140	10	0.312	0.066	6,000	—	—	7/16	3/4	5/8
0.156	9	0.343	0.072	7,500	—	—	1/2	13/16	11/16
0.171	8	0.375	0.078	8,500	—	—	9/16	7/8	3/4
0.187	7	0.406	0.085	10,000	—	—	9/16	15/16	13/16
0.203	6	0.437	0.091	12,000	—	—	5/8	1	7/8
0.250	3	0.531	0.110	15,000	—	—	11/16	1 1/8	1 1/8

1. SAE 1010 carbon steel and AISI 309, 310, 316, 317, 321, 347, and 349 stainless steel (Non-hardenable: 0.15 percent carbon maximum).
2. Material should be free from scale, oxides, paints, grease and oil.
3. Data based on thickness of the thinner sheet and for 2 thicknesses only.
4. Size of projection normally determined by thickness of thinner piece and the projection should be on the thicker piece wherever possible.
5. Contacting overlap does not include any radii from forming.
6. Weld should be located in center of overlap; if two welds, balance in center of overlap.
7. Projection should be made on piece of higher conductivity when using dissimilar metals for welding.
8. For diameter "D" a tolerance of ±0.001 inches in material up to 0.050, and ±0.007 inches in material over 0.050 may be allowed.
9. For height "H" a tolerance of ±0.002 inches in material up to 0.050 and ±0.005 inches in material over 0.050 may be allowed.

ameter. Relief should be added around both sides of the ring to allow for the flow of metal. Otherwise, there will be a separation or gap between the two parts. This gap will not affect the static strength of the weld, but it may detract from the appearance and cause fatigue failure.

If a ring projection is to be formed on a boss, the projection should be placed nearly in the center or at least far enough in from the edge that the hot metal cannot collapse around the outer edge. When placed around the edge, the metal is pushed outward around the circumference of the part, which makes a poor weld.

Ring projections do not necessarily follow the form of annular ring projections machined into the surface of the metal itself but can take several other forms as shown in Fig. 4. In (A) an inverted countersunk embossment in a stamping serves a dual purpose: As a pilot for locating the special stud, and as a natural "Vee" ring edge for projection welding to the

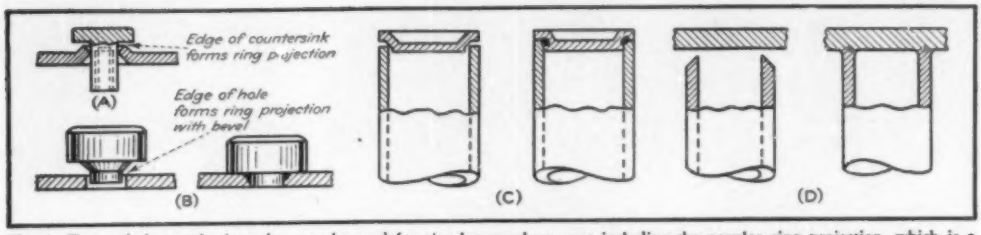


Fig. 4—Types of ring projections that may be used for circular members—not including the angular ring projection, which is a raised spherical ridge that is machined or formed on the flat member. Joints made by any of these methods are watertight.

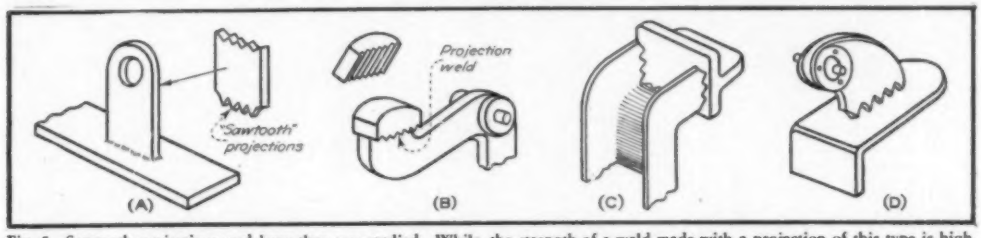


Fig. 5—Sawtooth projections and how they are applied. While the strength of a weld made with a projection of this type is high, the edges frequently mush out due to the lack of confining surfaces on the sides. Sawtooth projections are often used on stampings.

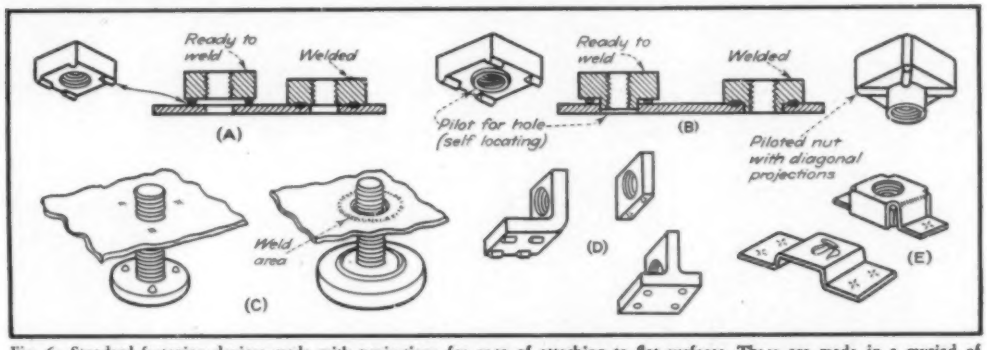


Fig. 6—Standard fastening devices made with projections for ease of attaching to flat surfaces. These are made in a myriad of shapes and sizes, the special nut clips bottom (E) being available in at least 53 varieties. All types result in fast assembly.

sides of the studs. As the welding current is applied to the parts, the collapse from the heat of the ring edge permits the head of the stud to be brought into intimate contact with the flat surface of the sheet metal stamping and a water tight ring projection weld is made to both the head and the shank of the stud.

A slight departure from this application is shown in (B), before and after welding, in which a 45 deg bevel is turned on the stud; the circular edge of the hole in the sheet metal providing a natural ring "vee", projection edge. This results in a 360 deg watertight joint between the stud and the sheet.

A further diversification as applied to tubing is shown in (C) in which the end of a tube is to be sealed by a sheet stamping having a drawn beveled edge. The bevel in the stamping, forms a natural "Vee" ring projection and results in complete sealing of the two parts into a gas tight, water tight weld.

A slightly different treatment of ring projection for welding tubing to a flat stamping is shown in (D) in which the tubing is beveled to make a "Vee" ring projection to be used against the flat part. The beveled preparation shown can take one of two forms: The projection can be machined with a single side bevel as shown, or the projection can be in the form of an annular "V" cut at the end of the tube. The resulting projection weld is excellent. Inclination of the apex of the projection to the outside or the inside of the tube will determine the direction of the mushing action of the weld. Therefore, in designs of this type, it is necessary to first decide whether the contacting surfaces should form a sharp edge on the outside of the assembly or on the inside.

Cross Wire Projections

One of the most common and inherently successful forms of projection welding is the cross wire method used to form rods and wires into baskets, grates, grills, and concrete reinforcements.

Round wire forms a "natural" projection but a very unsatisfactory cross wire projection weld results when the flat side of a rectangular wire section is to be welded to the flat side of another rectangular or square section.

There is no concentration of welding current, so the cross wire welding would be improper. Solutions to a cross joint of flat sections are (1) to individually spot weld the center of the parts, (2) to place a formed projection in one or another of the two parts, or (3) to place one edge against the flat part of the other wire so that the corners form a natural apex contact between the two parts. Thus, a small area is concentrated at the intersection, producing a very effective weld. Square wires, when turned edge to edge, tend to produce a mushing of the weld at the sharp edges.

Sawtooth Projections

The "sawtooth" type projection is used on the edges of certain stampings. The strength of this type of projection weld is high but is nearly always accompanied by "mushing" at the edges of the stamping because there are no side surfaces to confine the flow of metal when it is in plastic state. Many times, sawtooth projections are used to insure breaking through the coating or plating on clad, coated or plated materials.

In Fig. 5(A) is shown a common type of 90 deg butt projection weld made at the intersection of two flat metal parts in planes 90 deg from each other; preparation of sawtooth projections in the upper part is a simple die blanking operation. At (B) is a silver contact button projection welded to an electrical contact arm; this is widely used in the electrical control equipment industry. A commonly used method for joining forgings or special curved stampings to end pieces is shown at (C). Exceptionally great strength is achieved in the special brackets (D) where the sawtooth projection is permanently and rigidly welded to the other part.

Welding of Nuts, Studs, and Small Parts

Many of the joints just discussed are in themselves suggestive of applications for the projection welding process, but one use is of sufficient importance to justify a more thorough treatment: Namely, projection welding of nuts, studs, and other fasteners and small parts. By the use of standardized weld nuts, studs, and cups on which projections are formed, many products can be fabricated at a considerable savings in production cost.

Several different fasteners and components designed for projection welding are shown in Fig. 6. A square nut with four corner projections is shown at (A) "before" and "after" welding. When this nut is used, a bullet-nosed pin or other means is used for locating the nut with reference to the hole in the metal part. The bullet-nose pilot must either be made of insulating material or a steel pin insulated from the welding dies to avoid shorting between the nut and the dies. Such insulation precautions must also be taken for studs. A spring actuated retainer of insulated material holds the studs in place until welded.

At (B) is one of many pilot type nuts with four corner projections and also one with four diagonal projections. These nuts are self-locating with reference to the holes in the assembly to which it is to be attached. If they can be used, these nuts are much easier to handle and locate than the type shown at (A).

One of the most advantageous welding aids and one used extensively throughout industry is the projection welded stud. Such studs, (C), are available in standard bolt lengths and diameters and in several varieties. The stud at the left with the three projections on the under side of the head and with the threaded portion extending through the plate provides a flush weld of high strength and in addition, is self locating. When the stud mounting must be water and gas tight, a 360 deg annular ring is used, which when welded, completely seals the head to the plate.

Often it is necessary to weld a nut at a 90 deg angle to the plane of the attachment surface. This is done by one of several ways such as (1), by the use of a 90 deg angle nut as illustrated at (D); (2) by the use of a plain nut having the projections on the edge; or (3) by the use of a *T* shaped nut, the projections being provided in the head of the *T* while the leg forms the nut.

Nut cages (E) are very quickly projection welded to enclosures or panels, to provide loose or "self adjusting" nuts for the attachment of bolted parts. The nut cage top has a projection on each side of the cage as indicated by the "X" mark. Nut cages are available with enclosures for one or several nuts and range in size from ¼ in. to 5 in. and 6 in. nuts. Special clips for special types of covers and special nuts, are commonly projection welded to sheet metal parts as shown in the bottom sketch. There are at least 53 "standard" varieties of such special attaching clips.

General Design Precautions

Projection welding, like other forms of resistance welding, can be overly designed or overly specified. Good design suggests that from the standpoint of the welding equipment, the forming, dies, strength, quality and uniformity of welds, only necessary welds should be specified. Three properly proportioned projections spaced at proper intervals on a part will result in a stronger weld than twice that number having incorrect proportions. Generally, also, the fewer the projections the easier it is to equalize pressure and current, since in a large number, one or two can easily be of slightly different height or size.

In welding dissimilar pieces, projections should be made in the part having the highest thermal and electrical conductivity; the part having the highest resistance will tend to heat more quickly and has less need for the projections. When using dissimilar thickness the size of the projections should be governed by the size required for the thinner of the two sheets. This is important as a projection of the size required for the heavier sheet would be disproportionate for the thinner sheet, and the thinner sheet would overheat.

Actually, if all the limitations, precautions, and rules for the design of projection welded joints were to be boiled down into basic principles, the following five would fairly well sum them up:

1. The projection should be sufficiently rigid to support the pressure applied by the welding electrodes or dies before the welding current is applied. If the projection is too large in diameter and too weak in proportion to the thickness of the piece being welded, insufficient heat will be formed and the joint will be nothing more than a "stick" weld.

2. The projection should have sufficient mass to heat the opposing surface to the correct welding temperature. If too small, it will collapse before the other surface reaches the correct temperature.

3. After being welded, the surfaces should be in intimate contact with each other, with no expulsion of metal or separation at the weld area. One method of preventing this is to provide a relief around the projection.

4. Projections must not be partially sheared or deformed during forming operation in the dies. Only in special circumstances should projections purposely be deformed or partially sheared, as is sometimes done in projection welding extremely thin parts such as tubing. Such welds lack the strength that would be imparted by using proper forms or projections.

5. Projection welds should cause little if any distortion of parts during the formation of the projections or in the actual welding operation.

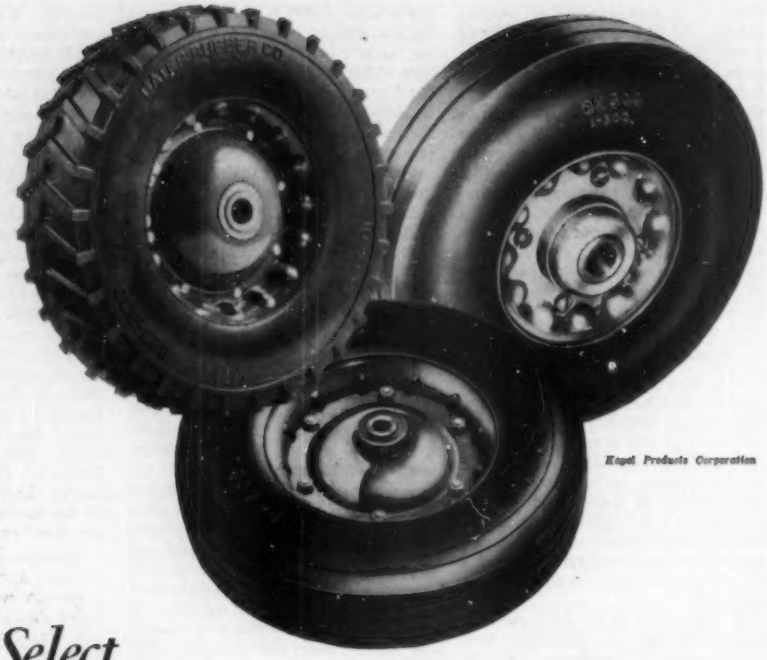


Fig. 1—Typical semi-pneumatic wheels, showing the variation in rims, treads, hubs and bearings, according to the load and service requirements of the particular vehicle on which the wheels are mounted.

Kopel Products Corporation

How to Select

Semi-Pneumatic Wheels

For portable tools, materials handling devices and other equipment where good appearance, low speed, low load per wheel, and puncture-proof qualities are desirable, semi-pneumatic wheels should be considered. By varying standard sizes, wall thicknesses, wheel assembly and bearings, designers can accommodate many different conditions.

THE SEMI-PNEUMATIC TIRE is a small, hollow extruded rubber tube cut to proper length and formed in a circular heated mold. A long hollow needle is inserted through an opening in the mold and through the side wall of the hollow rubber ring. Pressure is applied into the inside hollow ring through this needle, forcing the wall of the ring into the tire shape formed by the inside of the mold. Heat and pressure are maintained until the tire has been cured. The needle is then removed and the air within the tire escapes through the needle hole until atmospheric pressure is attained. The mold is then opened and the tire is removed.

The semi-pneumatic tire obtains its weight-carrying ability from the strength of the side-walls; and it is truly a puncture-proof tire, since there is no internal pressure. Flexibility of the side-walls gives excellent shock-absorbing qualities, and thickness of the side-walls determines the amount of load the tire can sustain.

Comparatively high speeds are obtainable with pneumatic-tired wheels because of their construction. The semi-pneumatic tire, which depends on its side-walls to hold loads, is not recommended for speeds greater than 10 mph, because the tire has a tendency to "creep" on the wheels. To prevent this creep, lugs are often molded in the ID of the tire. Fig. 2 shows the wall construction and dimensions of two sizes of semi-pneumatic tires.

Semi-pneumatic tires also have greatly increased shock absorbing qualities, when compared with solid tires, since shock absorption is inversely proportional to thickness of wall section. In this respect, pneumatic tires have the advantage over semi-pneumatics, since pneumatic tires generally have a thinner wall section than semi-pneumatics for a given load-capacity.

However, the semi-pneumatics have these advantages over pneumatics: They are structurally unaffected by

punctures, and allow the use of less expensive wheels than those required for pneumatics. The difficulties in maintaining proper air pressure, repairing punctures and replacing tires, have caused many manufacturers to switch from pneumatic to semi-pneumatic tires, in the small sizes. In changing from pneumatics to semi-pneumatics, however, there may be as much as a four-fold increase in dead weight of the tires used on a unit; but this is often a negligible consideration.

There are two common causes of failure in semi-pneumatic tires. First, overloading of tires can cause rim cuts or rupture of the tire through the seam. Second, even occasional excessive speeds will cause a fire-breakdown, involving excessive shock loads.

Selecting Proper Tire

Wheel and tire manufacturers have standardized on the following sizes of semi-pneumatic tires: 6 x 2, 8 x 1.75, 8 x 2.50, 10 x 1.75, 10 x 2, 10 x 2.50, 10 x 2.75, 12 x 3, 14 x 2 and 16 x 4. Semi-pneumatic tire sizes are identified by their outside diameter and cross-section (in inches) rather than the inside diameter and cross-section dimensions used for pneumatic tires. Industrial tires have several cross-section thicknesses because of varying factors in load and kind of surface on which the equipment is run. Medium and heavy duty tires of the same size arrangement are generally available. Smaller sizes, such as 8 x 1.75 and 10 x 1.75, are used on lightweight vehicles or lawn mowers. The large sizes, 12 x 3 to 16 x 4, are used on heavy power mowers, garden tractors, and other applications where load exceeds 400 lb per wheel. Generally, tires with less load deflection can be used in higher-speed applications. Allowable speeds depend entirely on amount of tire deflection. Soft turf or sandy soil require the wider type tread for better gripping surface, where narrower treads could be used on hard type floors. Larger diameters are preferred on wheels that are used on uneven floors and over curbs.

Unique sizes of tires are costly. Specifying odd sizes means special molds, and an immediate capital outlay. Often these sizes must be produced in single cavity molds. As a result of the cost of fabrication, special sizes are much more expensive than the 9 or 10 popular sizes for portable units, which are produced as a standard line and enjoy the advantages of long production runs. In addition higher tire inventories for special tires must be carried to maintain production schedules, and orders for tires may have to be placed months in advance. Each of the standard tire sizes can be considered to have the following rated loads:

Tire Size, in.	Rated Load, lb. (medium duty)
6 x 2 (solid)	250
8 x 1.75	80
8 x 2.50	150
10 x 1.75	100
10 x 2.00	100
10 x 2.50	165
10 x 2.75	185
12 x 3	230
14 x 2	140
16 x 4	425

Three important factors in selecting the proper tire and wheel must be considered: (1) Load and weight of vehicle; (2) selection of the correct tire (one having a higher rated load than the design load), and (3) selecting the proper bearing.

Loads should be distributed so that each wheel carries the same amount, whenever possible. When this cannot be arranged, the designer should not specify varying wheel sizes to obtain varying load capacities. He should, rather, standardize on one size of wheel and use wherever possible medium or heavy duty classes of tires.

It is advisable to use the largest size tire compatible with the overall appearance of the unit; this contributes to ease of rolling. However, the larger the tire diameter, the more attention must be given to rim design and tire mounting procedures.

To determine the load carried by the tire the following information is necessary:

1. Total weight of vehicle.
2. Weight of capacity load, if the vehicle is a cart or truck.
3. Number of tires carrying the load.
4. Center of gravity or distribution of load.
5. Distance between the center line of gravity and the wheel axles.

For four-wheeled carts or trucks in which the weight of the contents is evenly divided, capacity load is added to the weight of the equipment, and each tire then carries one-quarter of the total load. However, if a piece of equipment supports the larger part of its load on two wheels and the greater portion of the other two wheels, a few more calculations are necessary: First determine the maximum weight of the

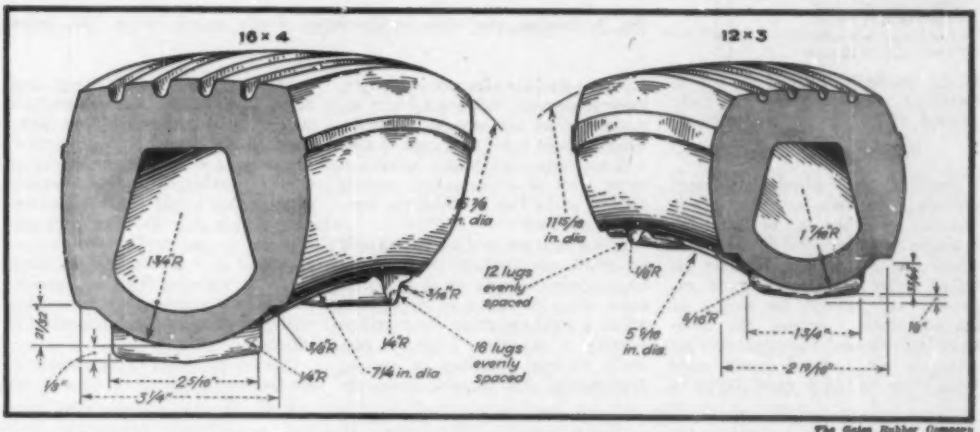


Fig. 2—Dimenisons of two sizes of semi-pneumatic tires. Lugs or grooves are molded in to prevent creep of tire around the wheel.

equipment and the location of the center of gravity. From a vertical line through the center of gravity measure the horizontal dimensions B (Fig. 3) to the center of the front axle L_1, and A to the real axle L_2. Maximum loads to be carried on the front and back axles are then calculated as follows:

$$\text{Load on front axle } L_1 = \frac{\text{Total weight} \times A}{\text{Wheel base } (C)}$$

$$\text{Load on rear axle } L_2 = \frac{\text{Total weight} \times B}{\text{Wheel base } (C)}$$

Should the weight of the equipment be evenly distributed between the wheels, then each wheel takes one-half of the total load on the axle. If a single follower is used at the rear of the equipment, it takes the total load L_1 on the rear axle. The designed load for the tire is equal to the actual load, just determined, multiplied by a service factor:

Vehicle Speed	Service Factor
Walking speed to 3 mph	1.0
Over 3 mph to 5 mph	1.1
Over 5 mph to 7 mph	1.2
Over 7 mph to 9 mph	1.4
Over 9 mph to 10 mph	1.5

If the vehicle is designed for use on extremely rough flooring or rocky ground, add 0.2 to the service factor.

Selecting the Wheels

Standard size wheels mentioned previously are made by several manufacturers in either one or two piece castings or stamped steel dished shapes which can be welded together or bolted. Cast wheels are more expensive and increase the weight of the equipment. Because the maximum loads on semi-pneumatic tires are relatively low, stamped wheels made from 14 to 18 U.S.S. gage (0.078 to 0.05 in.) steel are adequate in strength, more economical and give a better appearance than cast wheels. However, disks made of too light a gage of steel will not resist side thrusts, which can cause tears at stress points, usually starting at the hub in which the bearing is mounted.

Cast wheels are used most frequently on small run applications involving heavy loads, frequent abuse of equipment, much side thrust in service, and where a rigid mounting for precision bearings is required. These are generally material handling or moving applications. For portable tools, the widest use is made of stamped steel disks, in which the loads carried are mainly radial, and which lend themselves to economical mass production. The stamped disks are either welded or riveted together to form a one-piece wheel, or are bolted together for two-piece models (Fig. 4). The latter construction is preferred where tire replacement is a problem; this mainly occurs in materials handling applications. On a portable tool, the welded or riveted one-piece steel disk wheel is adequate.

The rim is shaped to the contour of the tire and the depth of the rim can

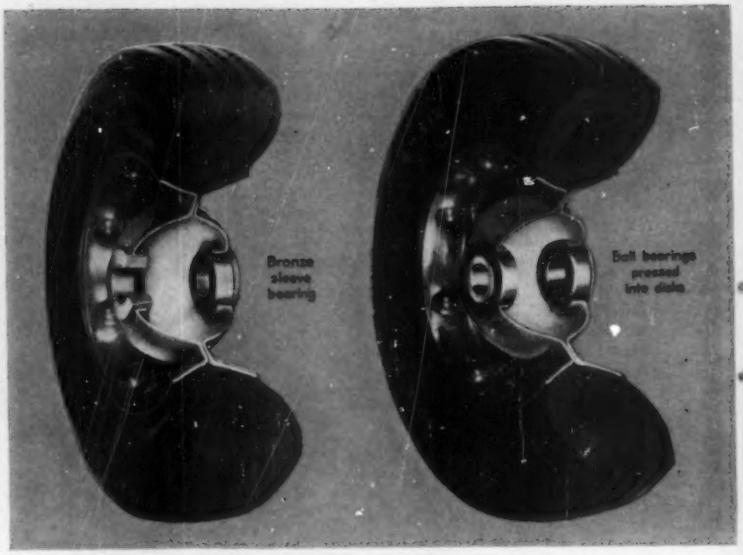
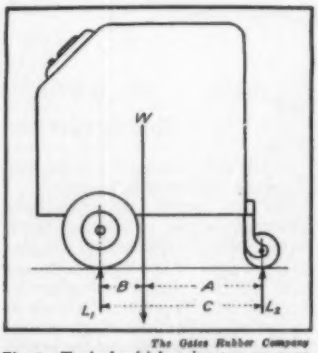
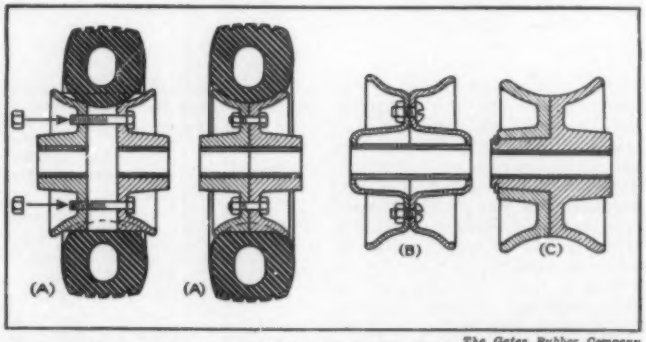


Fig. 5—Bearings used with semi-pneumatic wheels include sleeve, ball, roller,



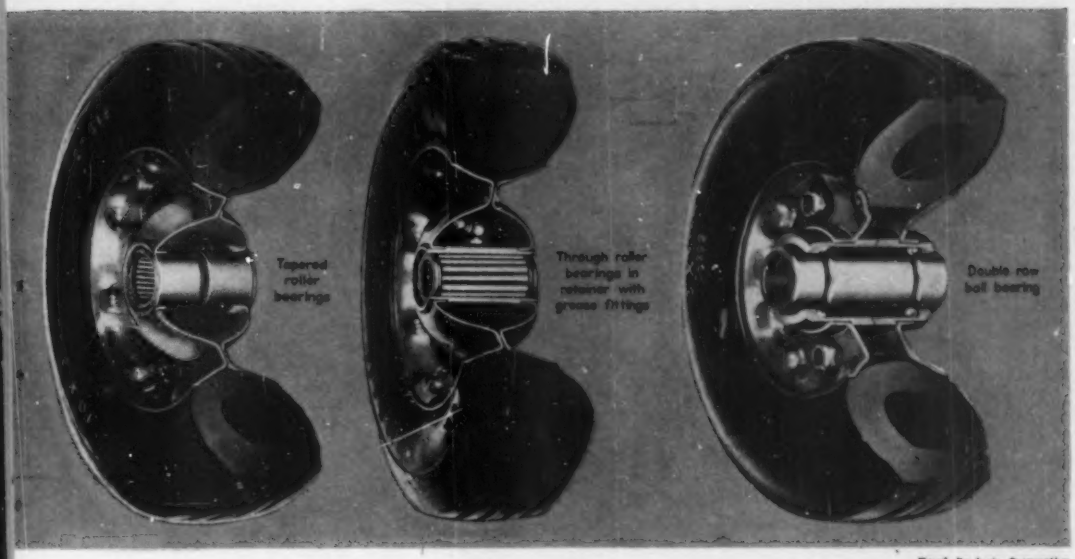
The Gates Rubber Company

Fig. 3—Typical vehicle using two or more pneumatic wheels. This equipment supports the major load on two wheels and a minor portion on the other wheels.



The Gates Rubber Company

Fig. 4—Two-piece wheels are easy to handle, as the tire is placed between the two wheel sections which are forced together in a press or by means of bolts (A). Such wheel sections can be cast or stamped: In (B), stamped wheel sections are fastened with screws; in (C) cast wheel sections are held with a snap ring.



Kayel Products Corporation

and pressed powder types, depending on service requirements. All bearings available in most sizes of semi-pneumatic wheels.

only be determined by fixing the process by which the tire is mounted. There are two methods in general use: (1) To mount the tire at the time the disks are assembled; (2) to mount the tire after the disks are assembled. The method of painting the wheel often determines the mounting process. If the wheel can be painted with the tire mounted, then the rim is made deep enough to keep the tire from rolling off in service.

When the stamped disks are welded together, the tire must be stretched over the rim of the wheel and snapped into position. This is usually accomplished with a tapered cone over which the tire is expanded. However, a rim that is bolted together can have high sidewalls. The wheels are usually made from 2 to 5 percent greater in outside diameter than the ID of the tire, assuring a tight fit under all loads.

On large diameter applications, keeping the tire seated in a wheel is a much greater problem, especially if the unit is used on sharp inclines and uneven ground. The narrower the tread of the tire, the greater is this problem. Use of semi-pneumatic tires for wheels of more than 16 in. dia, carrying less than 300 lb of load, is uneconomical.

If the tire and wheel are designed with lugs and corresponding grooves, it is important that the grooves and lugs are in proper alignment during installation. The grooves in the rim should be the same size as the lugs on the inner circumference of the tire.

The axle to be used with the wheel should be designed to carry the maximum load recommended for the tire. If the axle is sprung by overloading, the wear will be concentrated on the inside ribs of the tire tread.

Bearing Selection

Next to the tire, bearings used on semi-pneumatic tire wheels are the most expensive element. Most stock wheels are designed to fit either $\frac{1}{2}$ or $\frac{3}{4}$ in. axles. This has made practical the use of unground ball bearings, which in these sizes are economical.

Where wheels are used on equipment that gives little thrust on the axles, a bearing that is pressed into the steel disk of the wheel is adequate. For light, easily moved loads ball bearings are preferred. For medium loads where economy is a factor, bronze-lined bushings can be used; however, for heavier loads and where equipment is subjected to sudden drops creating shock loads, roller bearings should be chosen. If the wheels are subjected to heavy side thrusts, a long roller bearing having a through retainer, with grease fittings and sealed with washers or end plugs, should be used. By milling a flat on each end of the bearing retainer, the bearing retainer can be kept from turning in the wheel disk. A hardened tubing spacer can be inserted if the wheel is mounted in a fork type caster. In addition to allowing clearance between tire walls and the mounting fork, such a spacer also prevents excessive wear on the soft axle from the hardened rollers. Fig. 5 shows types of bearings that can be used with semi-pneumatic wheels.

Hub lengths vary according to usage, but protrusion of the hub from $\frac{1}{8}$ to $\frac{1}{4}$ in. beyond the overall width of the tire, is the generally accepted standard. In the 6 x 2 and 8 x 2.50 wheels the hubs protrude more because the grease fittings are used on the outside of the wheel rather than inside.

Ball bearings enable a wheel to spin easily, but wheels of this type are structurally weak, and the axle mounting must be so designed that nuts will not be tightened up, forcing the disks together. Often a sleeve is inserted in such wheels, at least 1/32 in. longer than the hub length, to prevent the disks from being forced together.

A better, but more costly solution is to use a separate hub section—usually a tube to which the disks are welded. The ball bearings are then pressed into the ends of this tube. Such a design can also be used with roller bearings. The cheapest bearing solution for light duty applications is to use a formed steel bushing flanged at both ends.

Ball or roller bearings should be used when the unit is in frequent motion, to minimize frictional drag.

EDITOR'S NOTE: This article is based on material supplied by Kayel Products Corporation, Detroit, Mich.; the Gates Rubber Company, Denver, Colo.; and Mr. Edw. Wisnewsky, Racine, Wis.

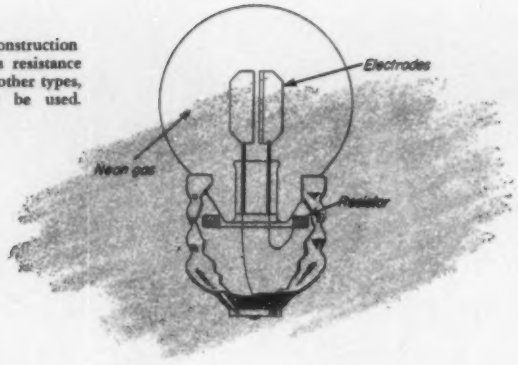


Fig. 1—Typical glow lamp construction Screw-base types have a series resistance inside the bulb, as shown; for other types, an external resistance must be used.

Neon Lamps For Indicators

E. W. BEGGS
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WITH THE DEVELOPMENT of more complex and sensitive industrial machinery and inspection equipment and the design of automatic electrical appliances and devices, small lamps are being applied in ever increasing number: (1) to indicate whether or not a device is properly connected in the circuit; (2) to show whether or not the circuit is "alive"; or (3) to give visual indication of the operating sequence of automatic machinery, the setting of a machine or the arrangement of the controls, or any one of many other conditions that exist with present day devices.

There are two basic types of lamps that can be used for such purposes—namely, the incandescent filament lamps and the less well known glow discharge or neon glow lamps. The small filament indicator lamp has a tungsten wire filament that produces visible light by incandescence and is generally of the vacuum type. These lamps are usually applied when both some degree of illumination and indication is required. On the other hand, glow lamps, in which the light is generated by a discharge of electricity through a gas, are especially satisfactory when only visual indication is required.

Lamps for most industrial indicator applications are subject to rough service. In this field the glow lamp is unsurpassed because of its simple rugged construction. It is a small wattage light sources that can be applied in conjunction with a small carbon type resistor at voltages as high as 450 to 600 volts, or as low as 110 volts a-c or 80 volts d-c. Essentially, these lamps consist of a glass bulb in which are sealed two electrodes coated with an emission material as shown in Fig 1. Neon gas is used to fill the standard types. When energized, the gas becomes ionized and current flows between the positive and negative electrodes, causing a characteristic orange-red glow to develop over the surface of the cathode (negative electrode). The lamps are often called "negative" glow lamps because only the negative electrode glows at any one instant. On d-c operation, of course, only the cathode glows while on a-c the polarity reversals are so rapid that both electrodes appear to glow together. This characteristic makes the glow lamp especially applicable for an inexpensive polarity tester.

The glow lamp possesses numerous other advantages such as long life, low wattage, distinctive color, small size and wide range of voltage operation. The standard line of glow lamps, Table 1, includes 1/25 watt, 1/10 watt, 1/4 watt and 1 watt sizes. As a result of the low wattage ratings, heat radiation is low. The entire lamp can be enclosed in a small housing, or can be molded into a transparent or translucent plastic without destroying the lamp or shortening its life by overheating.

The energy consumption of the 1/25 watt type is so small that the total consumed throughout its 25,000 hour useful life is only one kwh. The life of the glow lamp usually does not come to an abrupt end but gradually, as the lamp ages, it becomes dimmer and dimmer until the output reaches a point where the lamp is no longer useful. Actual average life to failure in general, ranges from 10,000 hr up, but the average useful life is rated at 3,000 to 25,000 hr, depending upon the type involved. This value is determined by the average time it takes the lamp to decrease in output to approximately 70 percent of the initial value. Since many glow lamps are used in applications where lower light outputs can be tolerated, actual useful life of the lamp may be correspondingly longer.

The initial light output of a neon glow lamp is small and since these lamps have generally been used to be seen and not see by, they have not been rated in terms of lumens. The orange-red color is especially useful for indicator lights because it is an "eye-catching" color and is easily distinguishable from surrounding light. No special red filters are required.

All glow lamps must be used in series with a resistor or other control to limit the current flow. Any vapor discharge lamp has a negative resistance characteristic and without a series control, an increasing current would flow, building up to destructive values. In some types, the resistance is assembled in the base, but for others it must be added in the external circuit. All standard neon glow lamps having a screw type base have the resistance

built in; others require an external resistor.

If the lamp is to be operated at higher than rated voltages, additional external resistance must be added. Radio type carbon resistors capable of dissipating about 5 watts are suitable for the largest lamp, the 1 watt size, while proportionally smaller resistors may be used for the lower wattages. It is important that moisture proof resistors be used to insure a good electrical circuit and long useful life of the lamp. Table II gives the approximate values in ohms of external resistors. Lower values than these will increase the light output but decrease the lift, and vice versa. The top limit of overload is reached when the current flow overheats the electrode and drives off the electron emission material. That loading will destroy the lamp immediately.

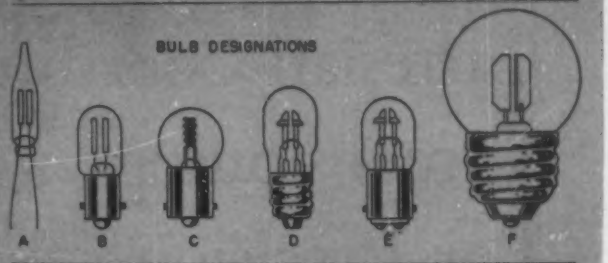
Where They Can Be Used

There are a wide variety of uses for glow lamps in industry—the most common being as pilot or indicator lights. When wired in parallel with a load, the lamp glows when the load is connected. In some cases, if desirable, the connection can be made from the line through the load so that the lamp gives a positive indication when the load is disconnected. Indicators of either type are commonly used in automatic control equipment, control panels, calculating machines, appliances, heating devices, circuit breakers, transformers, inspection equipment, coil machines, fuses, and many others.

The life of the glow lamps is generally not affected by the number of starts and they are, therefore, particularly well suited for intermittent or flashing service. They can also be subjected to a momentary overload each time they are flashed as long as the electrodes are not actually overheated, but extreme instantaneous peaks in the wave form must be avoided as they tend to sputter off electrode emission material and shorten lamp life.

The flash of a glow lamp is practically instantaneous, there being no appreciable delay or carry-over, so they are often used to indicate the rate of charge of a capacitor discharge circuit and for low level stroboscopic lighting for studies of rotating machines. In the latter case, the lamp is operated on an a-c circuit of known frequency or on d-c, connected in parallel with a capacitor and in series with a resistor to provide a relaxation oscillator circuit. If the resistor is variable, these lamps can be used to check rotational speeds such as that of commercial wattmeters and small rotating machines where their low light output is adequate.

Table I—Performance Characteristics of Neon Glow Lamps



Operating Characteristics	Nominal Wattage						
	1/25	1/25	1/10	1/4	1/4	1.0	1.0
Construction	A	B	C	D	E	F	F
Lamp number	Ne-2	Ne-51	Ne-26	Ne-45	Ne-48	Ne-30	Ne-56
Volts (Circuit)	105–125	105–125	105–125	105–125	105–125	105–125	210–250
Bulb Diameter, in.	1/4	13/32	3/4	9/16	9/16	1-3/8	1-3/8
Base type	Unbased Wire Term.	S. C. Min. Bay.	S. C. Bay. Cand.	Cand. Screw	D. C. Bay. Cand.	Medium Screw	Medium Screw
Max. overall length, in.	11/16	13/16	17/16	1-5/8	1-1/2	2-3/16	2-3/16
Average useful life, hr	25,000	3,000	3,000	3,000	3,000	3,000	3,000
Approx. starting voltage—							
a-c	65	65	80	65	65	60	60
d-c	90	90	110	90	90	85	85
Series resistance, ohms	200,000 External	200,000 External	50,000 External	30,000 Internal	30,000 External	4,800 Internal	40,500 Internal

Table II—External Resistor Value in Ohms For Higher Voltage Circuits

Operation Of Glow Lamps On Higher Voltages—A glow lamp may be used on higher voltage circuits if the proper value of external series resistance is provided to absorb the added voltage. The table gives the approximate value in ohms of the resistors required for the listed lamp types. This amount of resistance is needed in addition to that provided for the lower standard voltage. The resistor may be of the nearest standard value.

Glow Lamp	250 to 300 V	300 to 375 V	375 to 450 V	450 to 600 V
NE-2 ..... NE-51	750,000	1,000,000	1,200,000	2,600,000
NE-26	275,000	375,000	500,000	650,000
NE-45	82,000	120,000	150,000	200,000
NE-48	110,000	150,000	180,000	240,000
NE-30	13,000	18,000	24,000	33,000

Several neon glow lamps can be used together to produce a synchronized flash, increasing output for easier visual indication.

They can also be used to indicate circuit faults, to test capacitors and other electrical devices, to test for grounded neutral wires, or to indicate "hot" high tension circuits by capacitive coupling. Negative glow devices also have been used as voltage indicators or voltage regulators. However, when such indication or regulation must be within close limits, standard neon glow lamps are not recommended since breakdown voltages may vary considerably between lamps, change slightly with age, and may be materially lowered by strong light radiation that causes photoelectric emission at the electrodes and the breakdown voltage to be lowered somewhat.

Cartesian-Coordinate Dimensioning For Precision Components

A method for dimensioning complex, precision parts to simplify drawings and increase manufacturing accuracy. The *X-Y* dimensioning practice offers further advantages in application with the principle of minimum constraint.

B. L. HUMMEL
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DIMENSIONING by Cartesian coordinates is a convenient method for specifying hole locations and irregular contours of flat parts. Applied even in only arbitrary fashion, *X-Y* definition of point locations offers advantages in design. It simplifies calculation and checking of location for related parts in an assembly. It relieves the congestion of dimension lines and leaders on part drawings, which results from conventional dimensioning practice.

But greater benefits are realized if coordinate dimensions are established in relation to prime reference or datum points of a part. Violating the principle of reference to datum points, lines, or planes, by any dimensioning method, too often nullifies the accuracy built into tools that are capable of producing high-precision parts. Failure to observe this principle confuses the interpretation of inspection data.

To achieve maximum precision from the tooling, and to provide the basis for direct inspection procedures, the principle of minimum constraint should be observed when applying this dimensioning technique. The principle of minimum constraint is that flat parts are to be located on work plates or fixtures by the fewest means needed to secure the part, with neither excessive freedom nor strain. As demonstrated later by examples, coordinates are naturally adaptable to dimensioning for minimum constraint.

Cartesian-coordinate dimensioning has been used generally for many years in the watch-manufacturing industry. It originated with the introduction of coordinate-principled measuring and boring equipment, which was developed to attain the increased accuracy required in wristwatch production. The methods here outlined have been developed by the Hamilton Watch Company during recent years and employed in the volume production of small watch movements. Their use has reduced tool maintenance, promoted more effective inspection procedures, improved the degree of interchange-

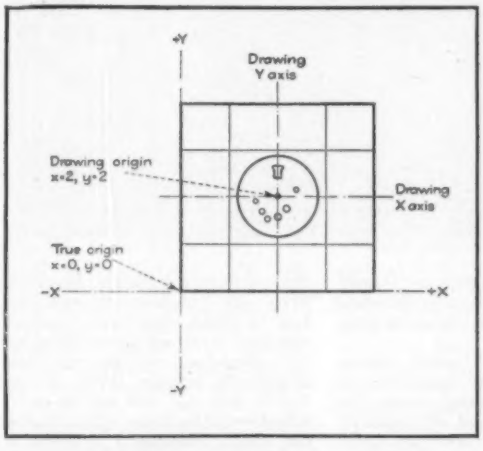


Fig. 1—Diagram showing Cartesian-coordinate field restricted to first quadrant to eliminate negative values.

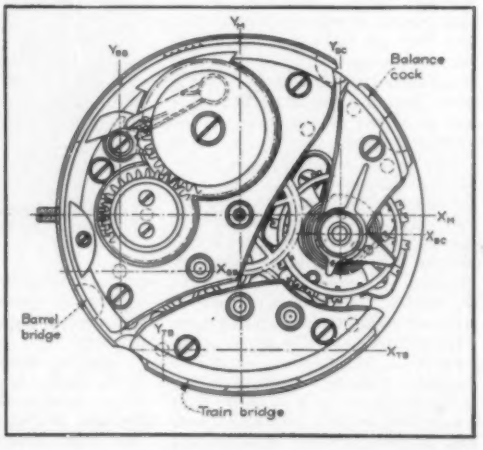


Fig. 2—Layout of watch movement showing parallel drawing *X-Y* axes systems for the assembly and for several components.

ability of parts, and influenced reduction in assembly and total costs of the product.

General Practices

The conventions of coordinate dimensioning are simple and flexible. They consist of rules and forms adapting classical Cartesian coordinates to practical requirements of engineering drawings.

COORDINATE FIELD: On drawings the coordinate field is restricted to the first quadrant, as Fig. 1 illustrates. Adherence to this rule is mandatory to eliminate the errors and confusion that would surely arise with negative values.

Convenient *X*- and *Y*-axis lengths are chosen, dependent upon the size range of assemblies and parts normally encountered. For watch-part dimensioning a 4-in. by 4-in. field is used most commonly.

As a matter of convenience and flexibility in the standard placement of varied parts in the field, the primary point on a part or assembly is assigned the coordinates of the center of the working area ($x = 2$, $y = 2$). This central point is termed the "drawing origin". Designation of an auxiliary origin scarcely conforms to the academics of coordinates, but this device serves a useful purpose. The true origin and axes cannot be shown conveniently on drawings if parts are situated centrally in a standard field of practical size. But the drawing origin and drawing *X* and *Y* axes can always be shown according to this system. The drawing origin accents the prime point of the part and the drawing axes define the directional significance of the coordinates. But all tabulated values of coordinates pertain to the original *X-Y* axes having the 0, 0 location.

ASSEMBLY LAYOUTS: During the design phase of a project, dimensional requirements of assemblies can be accumulated neatly and briefly by means of Cartesian coordinates. Almost always, plan-view details for many component parts must be established from a master assembly layout or checked against it, either directly by scale or by calculation with basic assembly data. Such interrelated details can be built up readily and cross-checked simply on one master axes system.

On the plan view all points requiring dimensioning for locations are numbered. The coordinates for the location of each are tabulated and identified by the same number, either on free area on the layout, or for complex assemblies, in a separate log book or file. It also may be helpful to label single pairs of coordinates or groups of them by suitable descriptive terms.

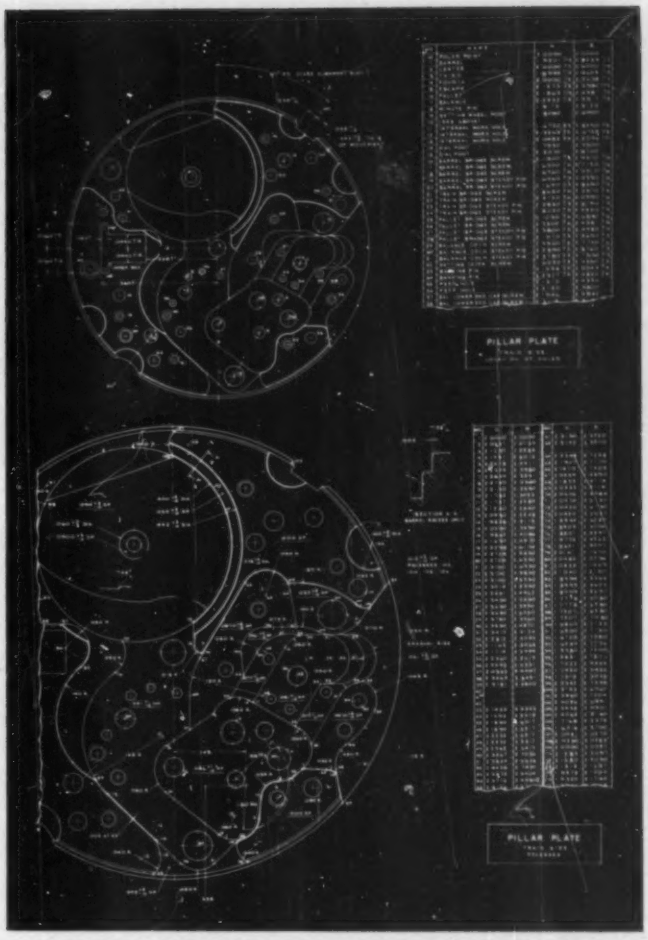


Fig. 3—Drawings showing hole-location and recess specifications for pillar plate of watch. Coordinate dimensioning greatly simplifies format of these drawings. Note that drawing origin has been transposed from center of watch to polar hole.

Because of the possible transposition of drawing origins and rotation of axes (discussed below) it is advisable to retain a greater number of decimal places for coordinates at each preliminary stage than may be required on the final working drawing. Premature rounding of coordinate values may cause errors in the final dimensions.

PARTS DRAWINGS: For each coordinate-dimensioned part of an assembly, a separate axes system is usually established. From the master coordinate log, dimensions can be transferred to an individual, parallel axes system for a part. This is done by adding or subtracting the *X* and *Y* differences between the assembly drawing origin and the point selected on the part as its drawing origin. Fig. 2 shows an assembly drawing axes system with axes for separate component parts.

The mechanics of parts drawings are shown by several drawing examples, Figs. 3 and 8. On the plan view, all points requiring dimensioning for location are numbered. The coordinates of each are tabulated and identified by the same number at the upper edge of the drawing. Generally, separate tabulations are given for hole locations, external and internal coutours. For hole locations, listing of the names of holes has proven helpful for functional references. The sequence of point numbers is arbitrary, but generally a stand-

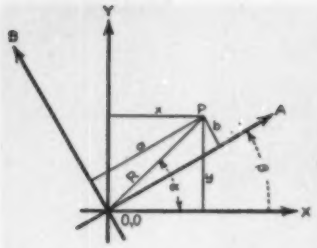


Fig. 4—Diagram for the general case of rotated axes. See text for derivation.

ard system facilitates drawing preparation and use.

How coordinate dimensioning simplifies the format of complex drawings can be appreciated from the figures.

Rotation of Axes

On the assembly layout the axes are generally oriented in a very arbitrary manner. In watch design, for example, the X and Y axes are located in line with 3 and 9 and the 12 and 6 o'clock positions of the dial. It would be extremely clumsy, however, to maintain the same directions for the axes on the individual parts. For a component, it is more desirable to set up a new axes system based upon the locating elements of the part. These elements may be those which locate the part in the assembly or which position it on work plates or fixtures during processing.

GENERAL CASE: In the transfer of coordinates from one arbitrary axes system to one rotated through a selected angle, it is customary to distinguish the two systems by denoting the original axes by X and Y, and those of the rotated system by A and B.

Fig. 4 illustrates the trigonometry of rotated axes. It is required that a point, P, located x and y distances from the true origin (0, 0) of an original X-Y system shall be expressed as a and b distances from the true origin of an A-B system rotated counterclockwise through the angle β from the original. R is the distance from the origin to the point, common to both systems. α is the angle between the original X axis and the line on which R lies. By simple trigonometric and algebraic operations

$$a = x \cos \beta + y \sin \beta \qquad (1)$$

$$b = y \cos \beta - x \sin \beta \qquad (2)$$

This solution holds for points located in any of the four quadrants about the true origin and for any angle of rotation. Proper algebraic significance must be given x and y and the functions of the angle β. The angle β is a constant, of course, for the calculation of all points within each case of rotated axes. Fig. 5 details the sequence for transferring coordinates from an X-Y to an A-B system.

INDIVIDUAL QUADRANTS: No difficulties should be encountered in applying the general solution above for any case of rotated axes, but errors in sign might easily occur when the A-B axes are rotated beyond the first quadrant.

Primarily as a detailing aid, the schedule of special, individual-quadrant solutions shown in Fig. 6 has been prepared. With it, calculations can be set up for angles of less than 90 deg, although to determine the proper form to use, the detailer must recognize the angle, counterclockwise, between the X' and A' axes.

WORK-SHEET METHOD: Transposition and rotation of coordinates from an X-Y to an A-B system can be performed most conveniently by a tabular work-sheet method. Fig. 7 shows one

Fig. 5—Calculation sequence for transposing and rotating coordinates from an X-Y coordinate system to an A-B system.

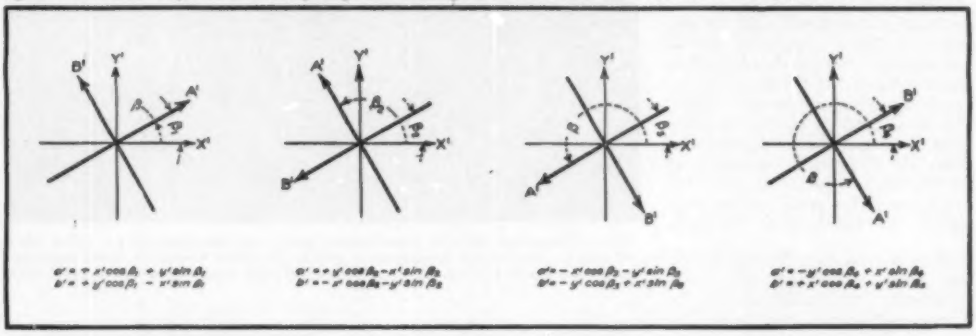
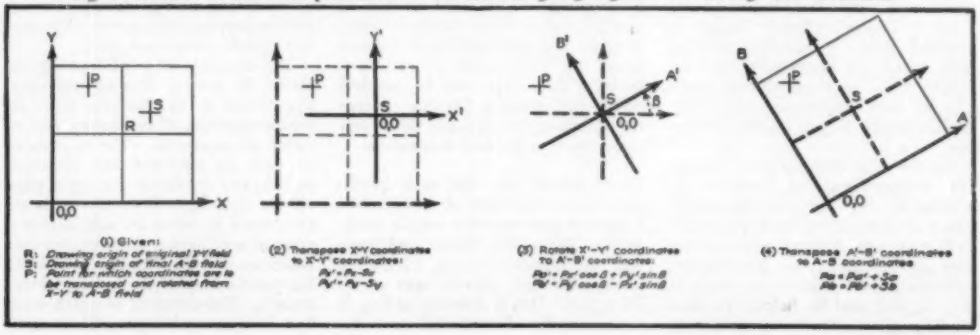
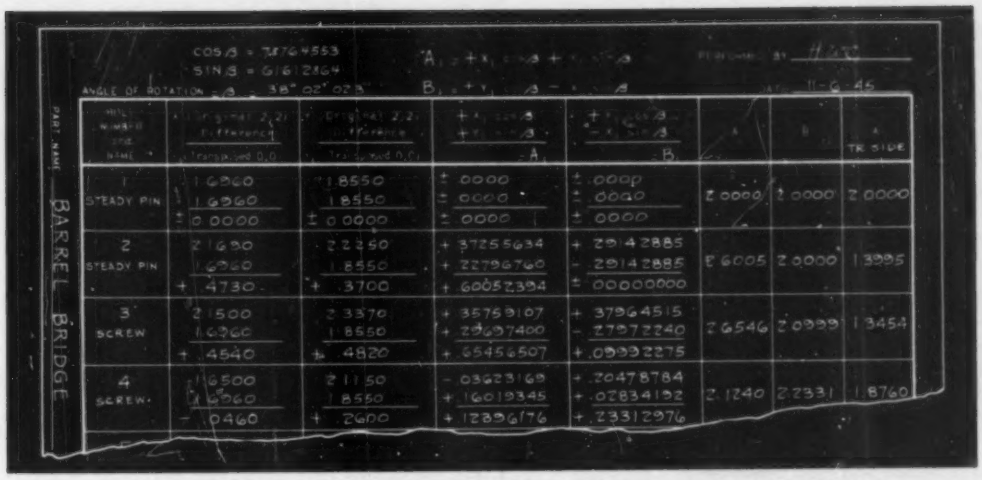

B'
Y'
A'
β
P
X'
α
a'
b'
a' = + x' cos β1 + y' sin β1
b' = + y' cos β1 − x' sin β1
a' = + y' cos β2 − x' sin β2
b' = − x' cos β2 − y' sin β2
a' = − x' cos β3 − y' sin β3
b' = − y' cos β3 + x' sin β3
a' = − y' cos β4 + x' sin β4
b' = + x' cos β4 + y' sin β4

Fig. 6—Schedule of individual-quadrant forms for eliminating angles greater than 90 deg. from calculations.


Y
P
S
R
0,0
X
(1) Given:
R: Drawing origin of original X-Y field
S: Drawing origin of final A-B field
P: Point for which coordinates are to be transposed and rotated from X-Y to A-B field
Y'
X'
(2) Transpose X-Y coordinates to X'-Y' coordinates:
Px' = Px − Sx
Py' = Py − Sy
B'
A'
β
(3) Rotate X'-Y' coordinates to A'-B' coordinates:
Pa' = Px' cos β + Py' sin β
Pb' = Py' cos β − Px' sin β
B
A
(4) Transpose A'-B' coordinates to A-B coordinates
Pa = Pa' + Sa
Pb = Pb' + Sb



COS β = .7764553
SIN β = .6312864
ANGLE OF ROTATION = β = 38° 02' 02"

PART NAME: BARREL BRIDGE

HOLE NUMBER AND SIDE NAME	Original X,Y Reference / Transposed X,Y	Original X,Y Reference / Transposed X,Y	+X cos β +Y sin β = A	+Y cos β −X sin β = B	A	B	TK SIDE
1 STEADY PIN	1.6860 1.6860 ± 0.0000	1.8550 1.8550 ± 0.0000	± .0000 ± .0000 ± .0000	± .0000 ± .0000 ± .0000	2.0000	1.0000	2.0000
2 STEADY PIN	2.1690 1.6060 + .4730	2.2350 1.8550 + .3700	+ .37255634 + .22786760 + .60052394	+ .29142885 − .29142885 ± .00000000	2.6005	2.0000	1.3995
3 SCREW	2.1500 1.6060 + .4540	2.3370 1.8550 + .4820	+ .35759107 + .29697400 + .65456507	+ .37864515 − .27872240 + .09992275	2.6546	2.0999	1.3454
4 SCREW	1.6500 1.6060 − .0460	2.1150 1.8550 + .2600	− .03623169 + .16019345 + .12396176	+ .20478784 + .02834192 + .23312976	2.1240	2.2331	1.8760

Fig. 7—Sample calculation sheet for transposition and rotation of axes for part illustrated in Fig. 8.

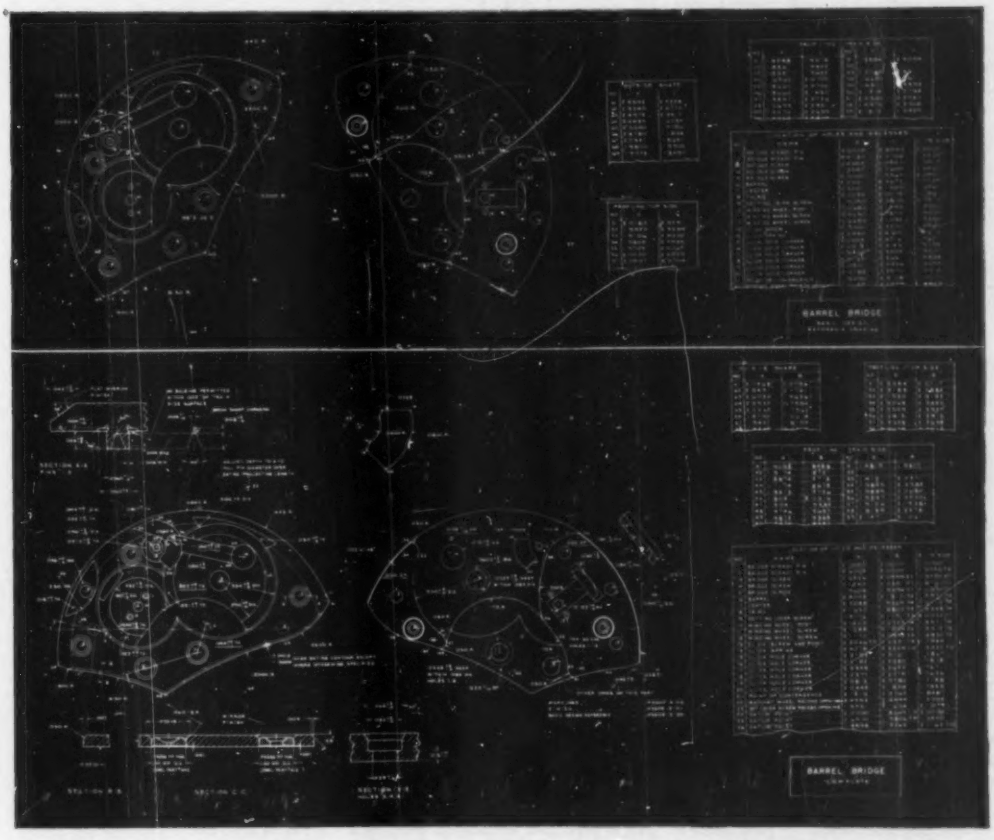


Fig. 8—*X-Y* and *A-B* drawings for barrel bridge of watch. The *X-Y* drawing is a record of coordinates transposed from the *X-Y* system of the assembly. Thus, it is convenient in the correlation of location information with that of *X-Y* drawings for other parts of the assembly. The *A-B* drawing is the actual working drawing. Its axes are generally not parallel to those of the assembly.

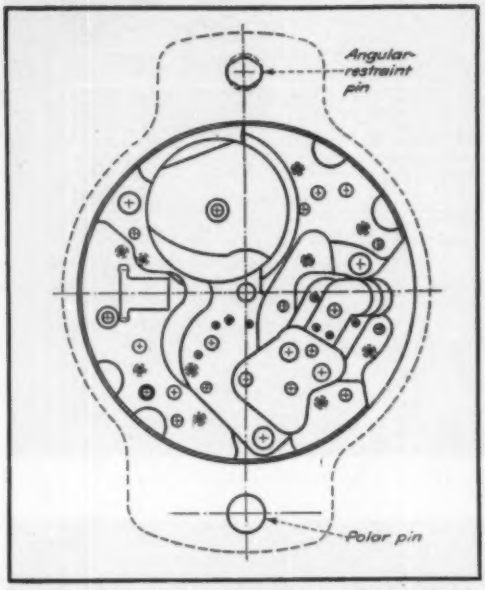


Fig. 9—Work-hole location of pillar plate according to principle of minimum constraint. Linear displacement is prevented by polar pin; rotation is opposed by angular-restraint pin.

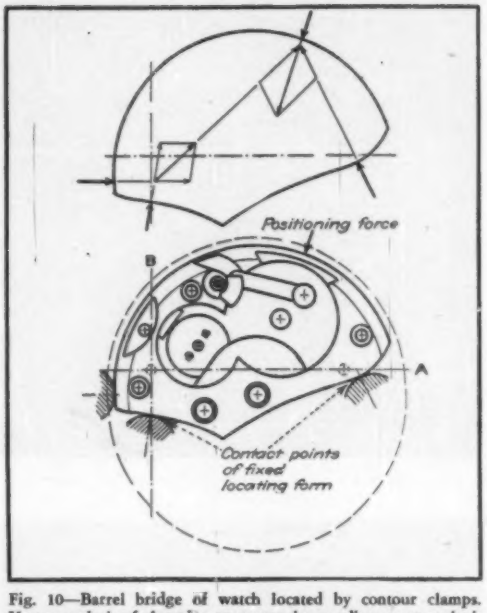


Fig. 10—Barrel bridge of watch located by contour clamps. Vector analysis of clamping pressures shows adherence to principle of minimum constraint with orientation of axes.

form of calculation sheet and a series of sample results. The *X-Y* design reference drawing and the *A-B* working drawing related to the sample calculations are illustrated in Fig. 8. The operations performed on the sheet are self-expanatory in conjunction with the illustrated drawings. Tediousness of the work is not great if a calculator is used for the multiplication operations. Since the angle of rotation is constant for a part, each of its functions may be left in the machine and only the x' or y' multiplier changed for each point.

Minimum Constraint

Translation of coordinate dimensioning from an arbitrary drafting practice to an effective engineering tool requires that proper physical significance be attached to the axes.

Since the axes are the datum lines from which locations are specified and deviations tolerated, their placement in direct relationship to prime functional points or lines of the part is essential. Particular value is gained from concurrent adherence to the principle of minimum constraint.

Minimum constraint simply means that a part is fixed in location by the fewest possible means. A part located on a fixture by only one work pin and one hole is "under constrained"; rotational freedom must be eliminated by at least one more constraining element. Normally, three pairs of work pins and holes result in "over constraint", because the third pair is unnecessary, at least as far as locating the part is concerned. Similarly, a part located in a nest, with total contour contact intended, is either over or under constrained according to the size variations of parts and wear of the nest.

This issue is vital when the acceptability of a part is dependent upon the accurate location relationships imparted to it by a series of dies or machining operations. When a consistent plan of minimum-constraint locating is used for all stages, successive set-up errors probably will be a minimum.

Thus, in dimensioning for minimum constraint, coordinate axes should be aligned with those elements of the part that locate it either in the assembled product or in work plates and fixtures. Sometimes only one of the two bases may occur. Other times both occur in an apparently irreconcilable manner. When the two sets of critical elements are not coincident, that set locating the part in the assembly is generally given precedence.

For example, when a part is located in an assembly by two dowel-pin holes, and is processed entirely in plan by a simple blank-and-pierce operation, only the dowel-pin holes need be considered. For a base plate upon which other parts are assembled, the axes are aligned with the means for locating the plate on processing fixtures. More difficult are those types of parts that are located in the assembly by dowel pins but are clamped at contour points for location on work fixtures.

To demonstrate Cartesian-coordinate dimensioning in satisfying the principles of minimum constraint, specific examples of the latter two constructions are detailed here.

WORK HOLES: The use of work holes is a traditional method for locating parts on work plates and fixtures. But although the preferred fashion of adapting the work-hole method to the principle of minimum constraint is generally known, it is overlooked many times. In terms of minimum constraint, only two pairs of work holes and pins are required. One pair, denoted by the term "polar", constrains the part linearly in all directions but permits rotation. The second pair, termed "angular restraint", serves only to fix the angular orientation of the part in relation to the polar pair.

This principle is illustrated in Fig. 9, which shows the base or pillar plate of a watch. The polar pair comprises a round hole and a close-fitting round pin. The angular-restraint pair consists of a round hole and a diamond-shaped pin. The relieved pin is so

oriented that it restrains the part against rotation about the polar pin but imposes no constraint in the direction of the axis passing through the two holes. The diamond pin allows for the occurrence of center-distance errors of reasonable magnitude of the pins or holes relative to each other. Therefore, the diametral clearance between a pin and its hole need not be enlarged to provide for center-distance differences. Consequently, "shake" of the part on the work plate is reduced to an extent essentially no greater than that required for the free fit of a single pin-and-hole pair.

In this application of Cartesian coordinates, the dimensioning axes are applied directly to the two work holes. The drawing origin ($x = 2$, $y = 2$) is assigned to the polar hole and the Y (or B) axis is aligned on the angular-restraint hole. The coordinates for all other point locations are given, thus, in direct reference to the means by which the part is located for all processing operations.

It is assumed in practice that the polar point possesses no location error in both X and Y (or A and B) directions, and that the angular-restraint point has no error in the X (or A) direction. The Y (or B) error is, of course, the center-distance error.

Equal bi-lateral tolerances are generally specified for all functional centers. The location-tolerance schedule, incidentally, may be included conveniently on the tabulation of coordinates on the drawing.

The methods outlined here have been applied successfully to the pillar-plate example in maintaining the location tolerances shown on the upper drawing of Fig. 3. Tool accuracy is essential for precision of this order, but the locating method is responsible for insuring consistency of results.

CONTOUR: Locating from the contour of an irregularly shaped part is frequently required when the use of internally situated work holes is not feasible. Cases of this type, exemplified by the barrel bridge of a watch illustrated in Fig. 8, are approached in two stages. The first is the placement of the coordinate axes to best meet functional requirements. The second is the determination of contour datum points by which the part is to be located on work fixtures.

Here, dowel or steady pins number 1 and 2 position the bridge on the pillar plate in the final movement assembly. Accordingly, the A and B axes are set directly on the pins so that all other point locations may be specified in direct reference to them. This setup again implies adherence to the principle of minimum constraint, for pin number 1 is assigned a location tolerance of zero in both A and B directions and pin number 2, zero tolerance in the B direction. For dimensioning and checking purposes, pin number 1 is the equivalent of the polar work hole and pin number 2 performs the same function as the angular-restraint work hole.

When processing this bridge, almost the entire outside contour of the part is shaved to finished size before the internal characteristics of the part are finished. Thus, for profiling, drilling, and shaving operations, the bridge necessarily must be located from the outside contour. Complete locating nests for this purpose are not desirable because of the hazards of over or under constraint. Also, errors of relative locations of the contour to the internal profiles or finished holes are difficult to analyze and correct. Causes of errors arising from imperfect peripheral contact are extremely elusive.

To meet the requirement of minimum constraint in this type of construction, contour datum points are selected as the regions against which locating clamps of the various fixtures will bear. Fig. 10 shows the sample part situated in a fixture. The points are so chosen that (1) locating forces will parallel or nearly parallel the axes established on the two dowel pins, (2) adequate stability of the part in the fixture will be insured, (3) clamping forces will be of nearly equal magnitude to prevent marring of the contour at points that might otherwise be overloaded, and to facilitate proper seating of the part by the spring clamp. The simplest way of meeting these several objectives is by vector analysis of the clamping pressures. Fig. 10 also shows this analysis for the sample bridge.

Parallelism of clamping forces and A-B axes is most important if control of processes and diagnosis of erors are to be conducted in relationship with directions of the two axes.

In addition to location, the contour-datum points also serve another useful purpose. Tolerances are assigned to each point in the single direction of the one axis that parallels or nearly parallels the bearing force upon it. These tolerances are limits of the relative location errors of the contour with respect to the finished pattern of pins and holes. As a rule, the size of the contour of the part is controlled within limits (shown by note on the A-B drawing in Fig. 8) without regard for internal details. The position of the acceptable contour relative to pins 1 and 2 is then checked against the tolerances specified for the datum points. Corrections to locating fixtures are made without complication because the action of each clamp is parallel, or nearly so, to one of the two axes.

Experience with this dimensioning practice has shown that successful application of coordinates is not limited necessarily to tooling and inspection facilities that operate on coordinate principles. There is no reason why other high precision products could not benefit from use of this method.

Sand or Mud Converted to Military Roads and Runways

SANDY BEACH STRIPS become paved roadways and muddy fields acquire surfaces safe for trucks by new processes announced by the U. S. Army and the Navy.

The Navy's primary interest is in hardening beach sands to help its Marines make amphibious landings; the Army's in muddy fields and coastal bog to make them suitable for movement of heavy vehicles, for landing operations and even for runway strips for airplanes.

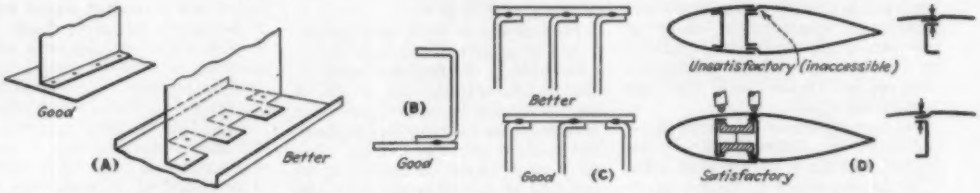
The Navy beach-sand hardening process involves low-temperature condensation and polymerization of two liquids through the introduction of a catalytic agent. Treated sand hardens in two to three hours, and after 24 hr is only slightly injured by trucks having a gross weight of 14 tons.

The Army process was developed by the Army Engineer and Development Laboratories at Fort Belvoir, Virginia, with initial research made by scientists at the Massachusetts Institute of Technology. The process, which takes less than five hours, is based on a wholly new principle of soil solidification that produces an elastic, rubber-like surface. It can be used on soils containing up to 30 percent water by weight.

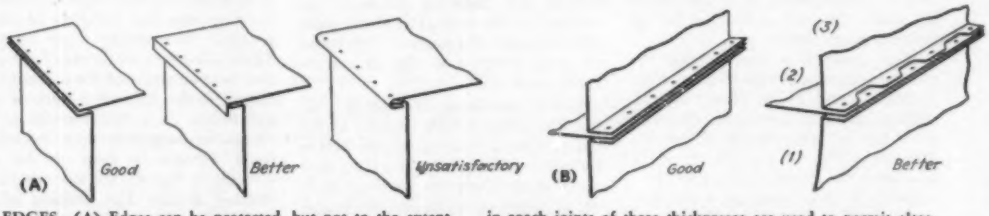
The actual stabilization process is based on calcium acrylate, an organic chemical that is absorbed by soil particles. Then come two other compounds, sodium thiosulfate and ammonium persulfate, which cause the calcium acrylate molecules to lock themselves together. The hardened mass withstands 20,000-lb wheel loads.

Spot Welded Joint Details

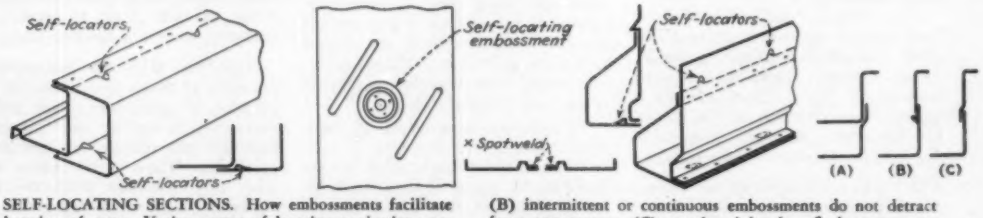
Edge design, methods of bracing corners, self-locating sections, and other details for spot welding. Schematic tips that will speed up



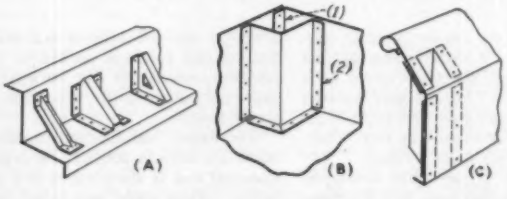
FLANGES. (A) Scalloped edges result in balanced welding stresses; (B) placing the weld at the fillet root increases mechanical strength; (C) turning a flange may decrease tooling and handling cost; (D) how flanges affect tooling.



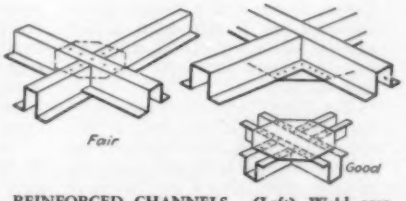
EDGES. (A) Edges can be protected, but not to the extent of covering the bottom of the weld area; (B) scalloped edges in coach joints of three thicknesses are used to permit alternate welding of spots in two thicknesses only.



SELF-LOCATING SECTIONS. How embossments facilitate location of parts. Various types of locating projections can be used: (A) An offset ridge is common on circular parts; (B) intermittent or continuous embossments do not detract from appearance; (C) overlap joint has flush appearance and provides positive location.



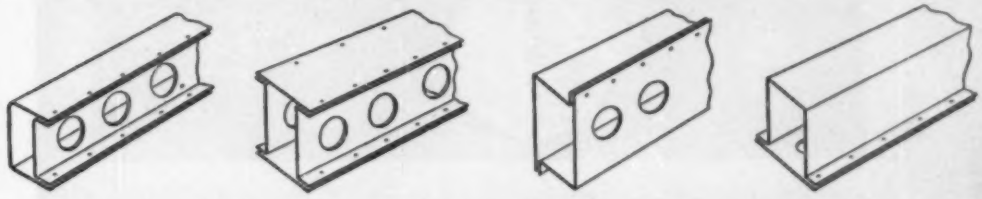
BRACES. (A) Ribs for aligning or strengthening a 90 deg. angle; (B) corner details for pockets or enclosures or to reinforce the assembly; (C) typical brace for angular section.



REINFORCED CHANNELS. (Left) Weld area inaccessible; (right) better than former but requires long electrode; easily welded.

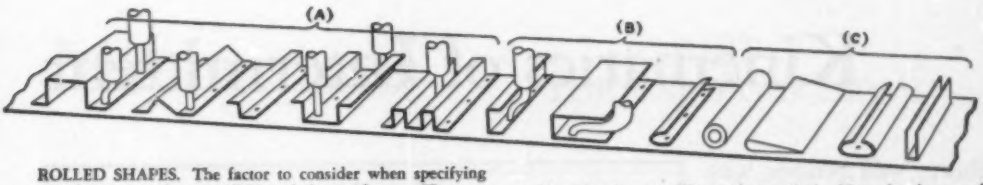
for Lower Cost Assembly

the actual welding operation, materially decrease the joining cost, and improve the quality of spot welded sections of any material.

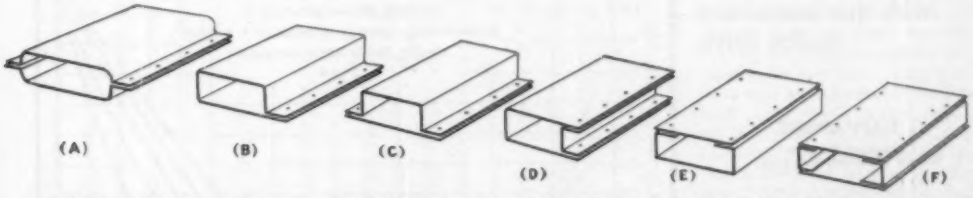


CHANNEL SECTIONS. Light metal structural members spot welded to make frames, enclosures, or reinforcements.

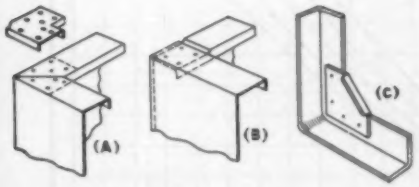
Large sections would be done on an automatic machine. All of the joints shown are relatively easy to make.



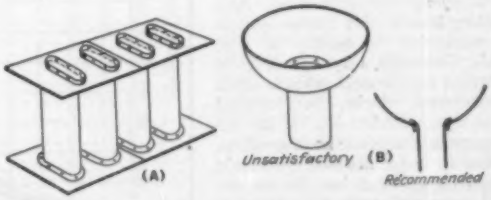
ROLLED SHAPES. The factor to consider when specifying rolled shapes is the accessibility of the weld area. Those at (A) are relatively easy to weld; those at (B) are more difficult; while those at (C) are impractical. Note the shape and size of the electrode required



ASSEMBLY DESIGN. Advantages and disadvantages of various designs: (A) Requires only simple tooling; (B) and (C) welded with flat electrodes to prevent marking; (D) weld areas are hard to get at; (E) even more inaccessible than previous design; (F) and (G) much too inaccessible and complicated.



CORNER DETAILS. Corner joints at (C) is probably more common and the least expensive to make; (A)-(B) requires specially shaped abutting sections.



CURVED JOINTS. (A) Comparison of accessible and confined cylinder ends; (B) recommended cylinder design, which is self-locating and does not require special electrodes.

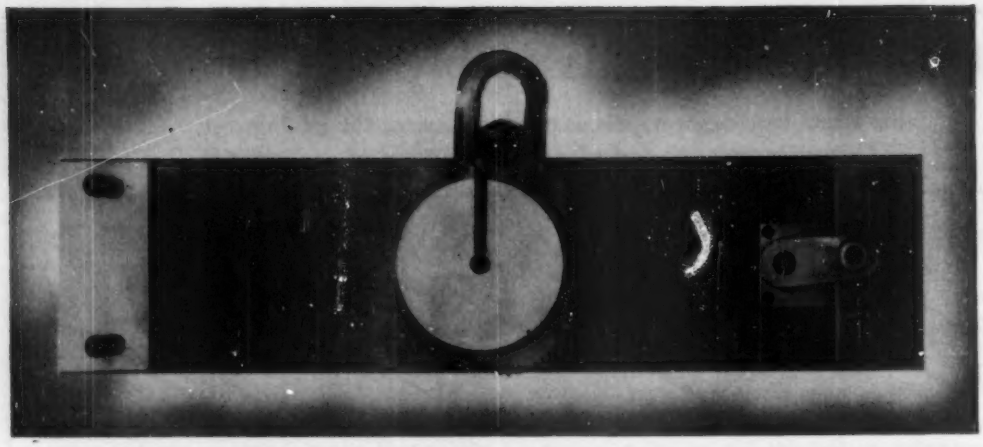


Fig. 1—Working model of the Cardioid drive. Dwell periods as short as a few degrees are possible with this mechanism. Therefore the acceleration forces are low and higher speed is possible. Use of transparent materials helps in motion study.

Kinematics of Intermittent

Short dwell periods, with correspondingly low accelerations, make possible higher speed operation with this intermittent motion drive.

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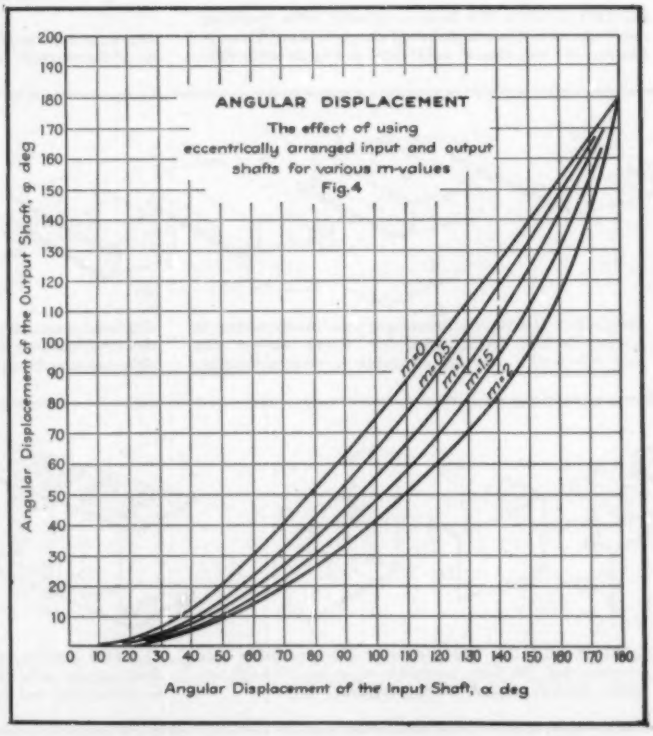
Consulting Engineer
Wright Machinery Company

INTERMITTENT ROTARY MECHANISMS with extremely short dwell periods have the inherent advantage of smooth operation because of the comparatively low acceleration forces involved. As a corollary benefit, this feature enables the mechanism to operate at high speeds. Obviously, a short dwell leaves more time for the mechanism to attain its maximum velocity, thus lowering the necessary acceleration. If the designer must incorporate an intermittent mechanism in his machine, he should choose the one that has the shortest dwell compatible with the given operating conditions.

An example, concerning a machine of European design for making cigarette tubes, illustrates this. A metal


ANGULAR DISPLACEMENT
The effect of using eccentrically arranged input and output shafts for various m-values
Fig. 4
Angular Displacement of the Output Shaft, φ deg
Angular Displacement of the Input Shaft, α deg
m=0
m=0.5
m=1
m=1.5
m=2
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

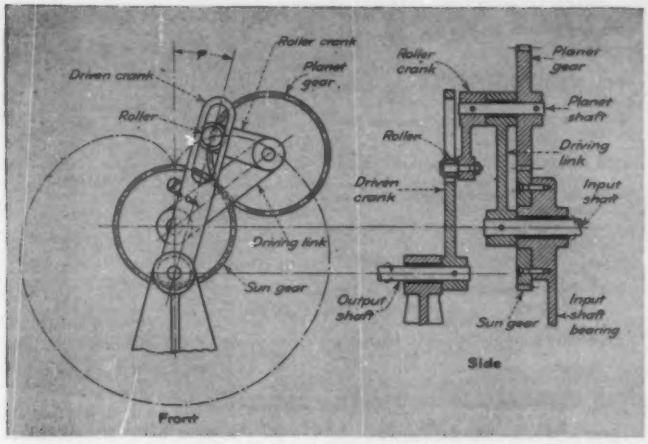


Fig. 2—Schematic arrangement of the Cardioid drive. Note that the front and side views illustrate the mechanism in two different positions of angular displacement.

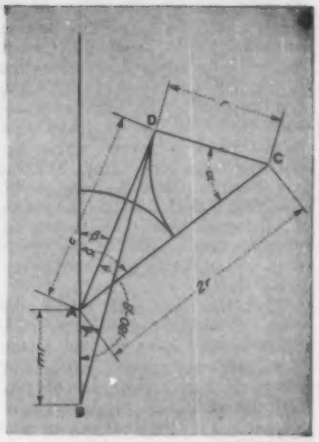
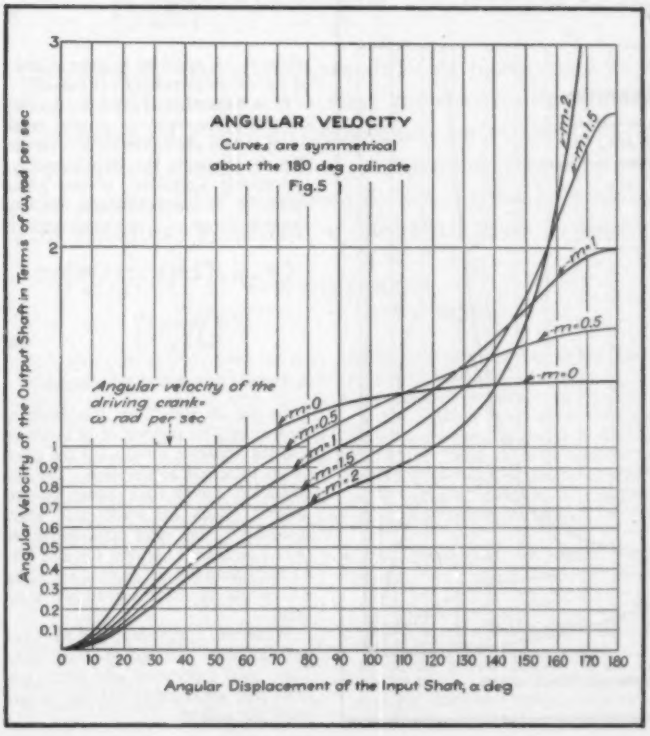


Fig. 3—Construction for calculating the displacement curve of the output shaft.

Mechanisms

PART V
THE CARDIOID DRIVE


ANGULAR VELOCITY
Curves are symmetrical about the 180 deg ordinate
Fig.5
Angular velocity of the driving crank = ω rad per sec
m=0
m=0.5
m=1
m=1.5
m=2
Angular Velocity of the Output Shaft in Terms of ω, rad per sec
Angular Displacement of the Input Shaft, α deg
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 2 3

tube of small diameter and having a longitudinal slot, received into this slot the heavy paper for the mouthpiece. The tube then rotated and the precut paper was wrapped around it.

Since the metal tube had to be motionless while the paper was fed into the slot, an intermittent drive was employed for the tube. This was first done with a mechanism of an unnecessarily long dwell period, 180 deg, which limited the speed of the machine to 240 rpm. Investigation showed that a dwell of only a few degrees would allow sufficient time to feed the paper through the short distance into the slot of the metal tube. The choice for such a suitable mechanism lay between the Three-Gear drive, PRODUCT ENGINEERING, Jan 1950, p 120, and the Cardioid drive, both having similar characteristics. Constructive and space considerations, however, favored the Cardioid drive, a model of which is shown in Fig. 1. In Fig. 2 a sketch is shown to aid in understanding the construction.

Use of the Cardioid drive made it possible to raise the speed of the machine from 240 to 650 rpm, without developing excessive forces or rough action.

The working principle of a Cardioid drive is shown schematically in Fig. 2. The name comes from the shape of

the path traced by the roller in the driven crank slot. The sun gear is fastened rigidly to the input shaft bearing, while the input shaft carries the driving link. Other end of the driving link carries a bearing for the planet shaft. On one end of the planet shaft the planet gear is fastened, and on the other end is the roller crank. The sun gear and the planet gear are of the same pitch diameter, $2r$, and the length of roller crank equal r. As shown, the roller fits into the slot of the driven crank, which in turn is fastened to the output shaft.

When the input shaft rotates, the roller follows the path of a cardioid, sliding up and down the slot of the driven crank and imparting to it, and thus to the output shaft, an intermittent motion.

Input and output shaft may or may not be located eccentrically to each other. Their center distance, mr, where m is the factor by which r is multiplied to equal the center distance, influences the characteristic curves. Usually m equals 1 produces satisfactory results by providing an apparent dwell of sufficient length for practical purposes and giving good acceleration characteristics.

Geometrical conditions from which the displacement curve can be calculated are shown in Fig. 3, using following notations:

Point A is the center of rotation of the input shaft.
Point B is the center of rotation of the output shaft.

r = pitch radius of both sun and planet gears.
α = angular position of driving crank at any time.
ϕ = angular position of driven crank corresponding to α
Point C is the center of the plant gear at the position α
Point D is the center of the roller at the position α

From the triangle ACD is found

$$c = \sqrt{r^2 + 4r^2 - 4r^2 \cos \alpha} = r\sqrt{5 - 4 \cos \alpha} \qquad (1)$$

$$\tan (\alpha - \beta) = \frac{r \sin \alpha}{2r - r \cos \alpha} = \frac{\sin \alpha}{2 - \cos \alpha} \qquad (2)$$

or

$$\frac{\tan \alpha - \tan \beta}{1 + \tan \alpha \tan \beta} = \frac{\sin \alpha}{2 - \cos \alpha} \qquad (3)$$

solving for $\tan \beta$:

$$\tan \beta = \frac{2 \sin \alpha - \sin 2\alpha}{2 \cos \alpha - \cos 2\alpha} \qquad (4)$$

From the triangle ABD is found

$$\tan \phi = \frac{c \sin (180 - \beta)}{mr - c \cos (180 - \beta)} \qquad (5)$$

$$\tan \phi = \frac{r\sqrt{5 - 4 \cos \alpha} \quad \sin \beta}{mr + r\sqrt{5 - 4 \cos \alpha} \quad \cos \beta} = \frac{\sin \beta \sqrt{5 - 4 \cos \alpha}}{m + \cos \beta \sqrt{5 - 4 \cos \alpha}} \qquad (6)$$

Substituting for

$$\cos \beta = \frac{1}{\sqrt{1 + \tan^2 \beta}}$$

$$\tan \phi = \frac{\tan \beta \sqrt{5 - 4 \cos \alpha}}{m\sqrt{1 + \tan^2 \beta} + \sqrt{5 - 4 \cos \alpha}} \qquad (7)$$

From Eq (4) and (7) is finally found the curve of angular displacement, Fig. 4, from:

$$\tan \phi = \frac{2 \sin \alpha - \sin 2\alpha}{m + 2 \cos \alpha - \cos 2\alpha} \qquad (8)$$

By differentiation of Eq (8) is found the curve of angular velocity, which Fig. 5 represents:

$$\frac{d\phi}{dt} = 2\omega \left[\frac{3 + (m - 3) \cos \alpha - \frac{m \cos 2\alpha}{2m \cos 2\alpha}}{5 + m^2 + 4(m - 1) \cos \alpha -}\right] \qquad (9)$$

where ω = uniform angular velocity of the driver in radians per seconds.

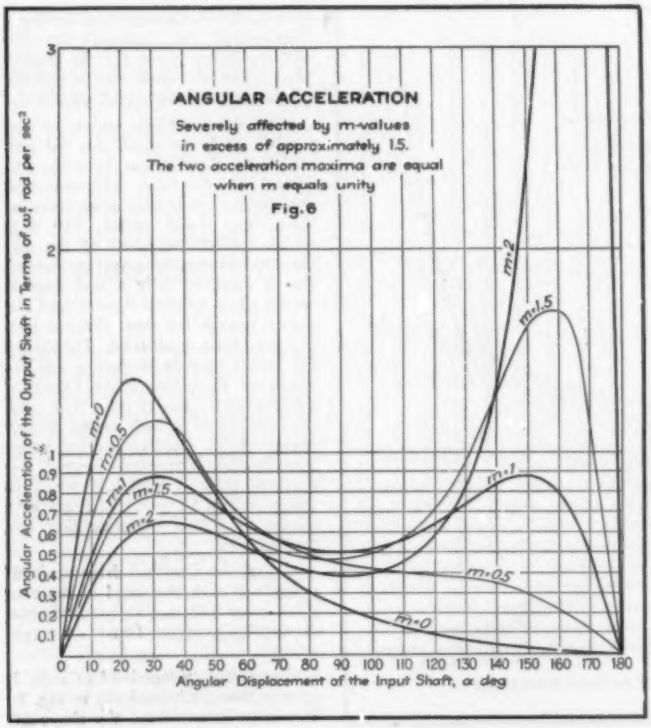
It is somewhat tedious to develop the second derivative in general terms of m, to find the acceleration curves of Fig. 6. However, the calculations are appreciably simplified, if the actual values of m are substituted. So, for instance, for $m = 1$, the acceleration is

$$\frac{d^2\phi}{dt^2} = 2\omega^2 \left[\frac{3 \sin \alpha - \sin \alpha \cos 2\alpha +}{9 - 6 \cos 2\alpha +} \quad \frac{2 \sin 2\alpha \cos \alpha}{\cos^2 2\alpha}\right] \qquad (10)$$

in radians per second per second.

As can be seen from the displacement curves, an increase of m increases also the apparent dwell—for the price of an increased acceleration. The acceleration curves have generally two maxima which are equal only when m equals 1. For most applications, m should be chosen between 0.8 and 1.5. As mentioned before, m equals 1 gives satisfactory results for average conditions.

Wherever practicable, the mechanism should be enclosed in an oil bath. Then good lubrication and protection from dirt are assured for the roller-crank slot contact.


ANGULAR ACCELERATION
Severely affected by m-values in excess of approximately 1.5.
The two acceleration maxima are equal when m equals unity
Fig. 6
Angular Acceleration of the Output Shaft in Terms of ω², rad per sec²
Angular Displacement of the Input Shaft, α deg
m=0
m=0.5
m=1
m=1.5
m=2
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 2 3

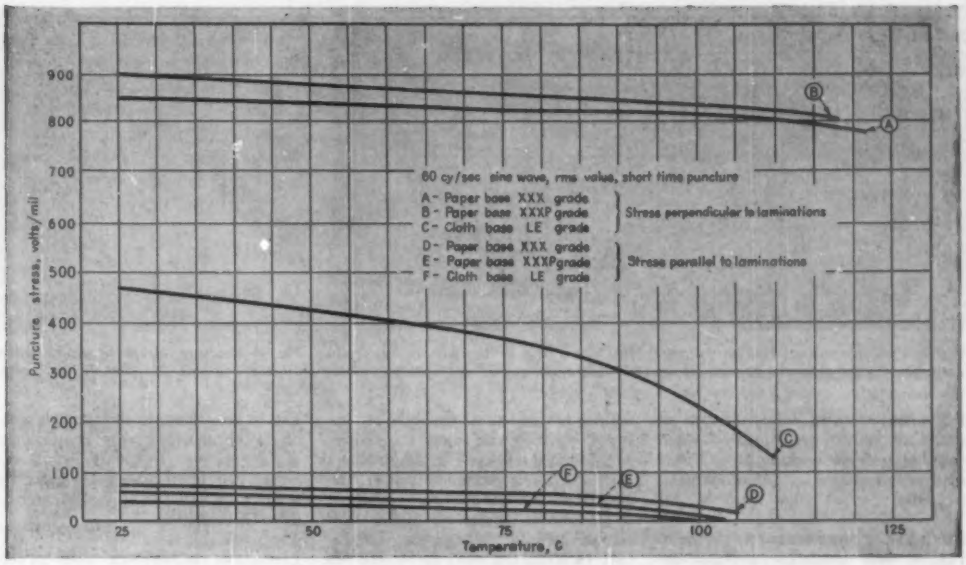


Fig. 1—Relationship of puncture voltage gradient and dielectric temperature in thin flat sections of phenolic resin laminates.

Laminated Plastics Insulation

Thermosetting plastic laminates are being increasingly used as electrical insulation where space and electrical losses must be minimized, and strength requirements are increased. Effect of surface and absorbed moisture, temperature, frequency and other factors on dielectric strength, dielectric loss and insulation resistance. Properties of electrical grade laminates.

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Chemical Department, General Electric Company

MODERN COMMUNICATION INSTRUMENTS are tending toward higher potentials and frequencies, with insulation problems becoming more critical at low energy levels. Losses must be kept minimum, as space limitations and strength requirements increase.

When flexural and impact strength are important, laminated thermosetting plastics offer excellent insulation, having fair dielectric properties, good strength and workability, lightweight, low cost, ease of assembly and are easily tailored for field replacement parts. These materials are given NEMA "grades" by the National Electrical Manufacturers Association, in their publication No. 46-118, entitled "Standard for Laminated Thermosetting Products."

Insulation properties of laminates can be classified by dielectric strength, dielectric loss and insulation resistance, and their relations to conditions of most interest to designers—the effects of temperature, moisture, voltage, frequency and conductor shape.

Dielectric Strength

There are many factors influencing puncture strength, interrelated and cumulative in effect, which can be studied separately.

INSULATION TEMPERATURE. Puncture strength decreases continuously with increasing temperature, finally reaching a value that is merely the voltage necessary to flow a current through a carbonized path, governed by the energy level of the circuit, when the temperature is sufficient to char the insulation. Reduction in puncture strength is not uniform, decreasing sharply at higher temperatures.

Fig. 1 illustrates the decrease in breakdown strength for ordinary temperatures; the upper temperature limit in laminated insulation, at continued stresses, is about 100 C. While intermittent short time temperatures above 100 C are allowable, their damaging effect under stress is cumulative.

TIME UNDER STRESS. Closely associated with temperature limitations is the time that stress is applied. Since energy loss in insulation is a function of time and is dissipated as heat, the rise in temperature caused by electrical current influences breakdown strength much the same as external heating.

The relative effect of puncture strength versus applied time is shown in Fig. 2. This relationship is part of the design safety factor for high voltage insulation. Under constant load, operating near the maximum 100 C

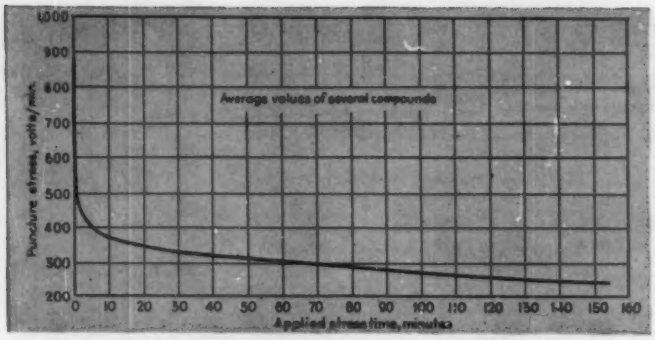

Fig. 2—Puncture voltage gradient versus applied stress time in thin flat phenolic resin laminates. Tested at insulation temperature of 25C, 60 cycles per sec sine wave, rms value.

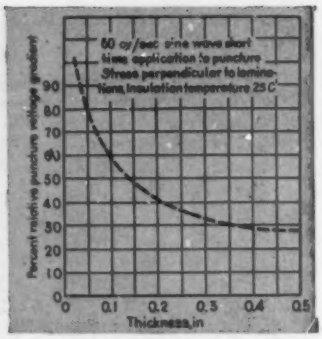
60 cy/sec sine wave short time application to puncture
Stress perpendicular to laminations, insulation temperature 25 C
Percent relative puncture voltage gradient
Thickness, in

Fig. 3—Puncture voltage versus insulation thickness in thin flat phenolic laminates.

temperature range, safety factors of about 10 to 20 are suggested when calculating a safe working stress. These apply for commercial power frequencies only.

INSULATION THICKNESS. As shown in Fig. 3, unit insulation strength decreases rapidly with increased insulation thickness. This is an important factor in insulation design, indicating that thin insulation, or multiple layers, give higher working stresses and reduce dielectric losses.

Care must be taken in multiple layer construction to exclude air gaps and foreign particles between layers; otherwise, breakdown from local overstress will result. This phenomenon is explained by the slower radiation of heat through the thickened insulation, dielectric rupture strength reducing with increased temperatures; with higher dielectric absorption possible in large insulation volume. Also influencing insulation strength is the possibility of individual fibers extending longer distances through the insulator.

EFFECT OF FREQUENCY AND WAVE SHAPE ON PUNCTURE STRENGTH. Since dielectric hysteresis losses increase directly with increasing frequency rate, and are mostly transformed into heat, the puncture voltage will decrease in proportion to the temperature increase, as for any temperature increase. The "skin" effect at very high frequencies tends to cause stress concentrations, to further reduce puncture strength.

Short duration impulses can have higher potentials than "normal" puncture voltages before rupture. Yet, steadily applied d-c stress will puncture at about the peak values of a-c voltage on a short time basis. This demonstrates that time, and therefore energy, is required in the breakdown process. Fig. 4A shows some probable relative values of puncture strength at impulse, d-c and sine wave frequencies in the lower ranges. Fig. 4B indicates relationships at common power frequencies.

Destructive effects of higher than critical impulse voltage are cumulative; each impulse starts the breakdown process, which is incomplete only because of the time limit. Succeeding impulses carry the process further, until breakdown paths are completed. Each insulation injury is permanent and reduces the puncture strength, although no appreciable heat accumulation occurs because of "rest periods" between impulses. When impulses are applied rapidly, breakdown strength will approach that of an a-c voltage of the same frequency; however, this will happen on a short time basis only, as the reversal of the a-c field causes more losses than unidirectional impulses of the same frequency.

For continuously applied direct current, heat generated is caused by surface and insulation resistance current only. At some point lower than critical stress, the heat will be radiated away at the same rate it is generated. At this voltage, the insulation will carry the load continuously without damage. In determining permissible working insulation voltage for each frequency, the fact that an insulator will transform electric loss energy into heat is used. Commonly called the "insulation power factor," this is the portion of energy in the charging current not returned to the circuit, because of imperfect elasticity in solid dielectrics. This loss value increases directly as frequency increases; therefore, puncture voltage drops at this ratio because of increasing development of heat.

At radio frequencies, the rate of reduction of dielectric strength with increasing frequency is greater than the reduction from temperature, as capacity reactance of the insulator drops also in proportion to the frequency increase, approaching very small values at "microwave" frequency, where the circuit can be insulated by inductive reactance and energy transferred through insulation.

INSLATION RESISTANCE AND PUNCTURE VOLTAGES. At critical stresses, insulation resistance is a very important consideration for low frequency and impulse work, as heat generated and accumulated by I^2R energy transfer will shortly reduce dielectric strength to a breakdown value. Since the electro-static field forces, influencing the line-up of moisture or conducting particles into chains, are in direct proportion to the voltage applied, insulation resistance is only constant at potentials less than critical values. Approaching critical stresses will cause local breakdowns, further increasing stress concentration. In general, low insulation resistance indicates low dielectric strength at low frequency; for short duration impulse stresses, the apparent dielectric strength may be many times its real value.

CONDUCTOR SHAPES AND SIZES. Puncture voltages for insulation depend largely on the shape of the electrostatic field, in turn determined by the shape and arrangement of the conductors. Any disturbance in the field lines causes a stress concentration with attendant higher voltage gradients. When approaching critical voltages, these concentrations break down first, charring locally, further decreasing electrode spacing and reducing puncture values. Fig. 5 illustrates the effect of electrode shapes on puncture.

In practice, it is frequently noted that good design of the electrodes and field through and around the insulator will allow a small insulator, working at a gradient utilizing full insulation properties. Such design is extremely

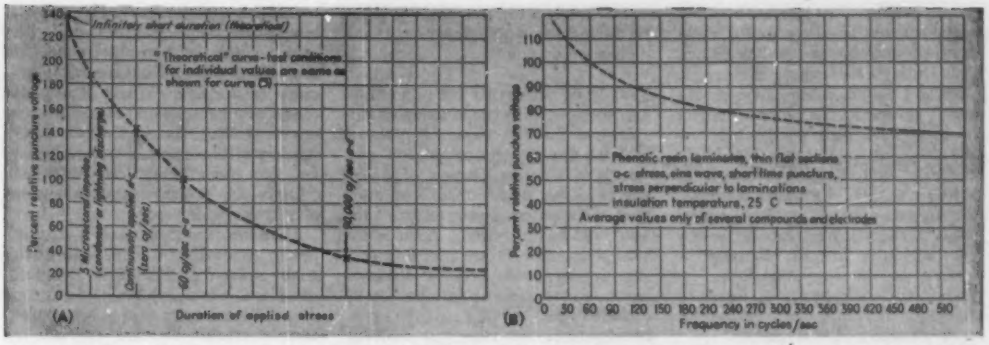
Infinitely short duration (theoretical)
"Theoretical" curve—test conditions for individual values are same as shown for curve (3)
5 microsecond impulse (condenser or lightning discharge)
Continuously applied a-c (60 cy/sec)
60 cy/sec a-c
10,000 cy/sec a-c
Percent relative puncture voltage
Duration of applied stress
(A)
Phenolic resin laminates, thin flat sections
a-c stress, sine wave, short time puncture, stress perpendicular to laminations
insulation temperature, 25 C
Average values only of several compounds and electrodes
Percent relative puncture voltage
Frequency in cycles/sec
(B)

Fig. 4—Relationship of puncture voltage to nature of applied stress in thin phenolic laminates. In both, 60 cy/sec a-c is assigned a value of 100 percent. In (A), curve is arbitrarily drawn. Curve in (B), based on more data, amplifies portion of other curve.

important when high voltages and limited space are involved. As shown in Fig. 6, size and heat conduction of the electrodes are important considerations, because of influence on insulation temperature.

ABSORBED AND SURFACE MOISTURE. Leakage current through an insulator at less than critical voltage is somewhat proportional to the amount of absorbed moisture; if the energy level is high enough, the heat generated will dry out some of this moisture. The initial leakage current will be high, gradually dropping back to the normal current for dry insulation resistance. In many applications, this initial leakage will exceed the available energy level, and disable the circuit, requiring some pre-drying and sealing for satisfactory operation.

The cumulative effect of the heat generated in drying out the moisture paths will reduce the puncture voltage in about the same proportion as previously described.

As critical voltages are approached, the effect of moisture is more marked. Field stresses tend to line up moisture particles into conducting chains, developing local breakdowns progressively and causing total puncture at much less than normal puncture voltage. Critical insulation should be designed on the basis of saturated dielectric strength, determined by tests at operating conditions, with large safety factors to cover possible temperature rise.

Surface moisture and dirt increase electrode size and reduce leakage paths. At some voltage less than critical, this condition causes progressive local breakdown, finally causing flash-over failure and carbonization tracks along the surface. Some plastics are made with special surfaces having better arc resistance for critical applications, where such flashovers are likely.

TOTAL APPLIED VOLTAGE. The relationship between stress gradient and dielectric strength can be explained as follows: For some working voltage, the insulation will not break down for an infinite time, for some higher stress the insulation will break down after a definite time, and so on until the applied voltage is high enough to cause almost instantaneous breakdown. Since the apparent dielectric strength varies with the time of application at a fixed voltage gradient, values of dielectric strength must include a factor derived from a time value for one voltage gradient.

For a given insulation distance or thickness, and infinite time under stress, the maximum safe potential is indicated by the voltage—temperature relationship indicated in Fig. 1, with a proper safety factor.

Dielectric Loss

INSULATION TEMPERATURE. Dielectric loss, or more correctly, dielectric absorption, is an imperfection of solid insulation. On a-c circuits, all of the charging energy absorbed from the conductors is not returned to the circuit as the voltage drops to zero at the half-cycle, and this portion of the energy transformed into heat. The reduction of "electric elasticity" in insulation with increased temperature is somewhat analogous to the reduced strength and elasticity in steel with increased heat.

A laminate insulation can be considered as a non-homogeneous structure made up of microscopic condensers and resistors, connected to-

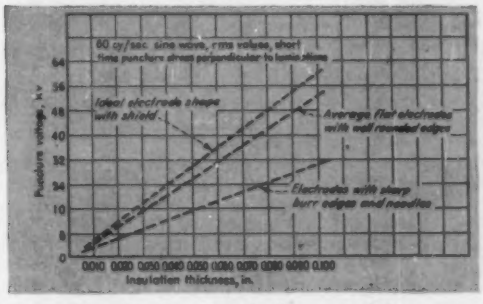
60 cy/sec sine wave, rms values, short time puncture stress perpendicular to laminations
Ideal electrode shape with shield
Average flat electrodes with well rounded edges
Electrodes with sharp burr edges and needles
Puncture voltage, kv
Insulation thickness, in.

Fig. 5—Effect of various electrode shapes on relative puncture voltage in thin flat phenolic resin laminate sections.

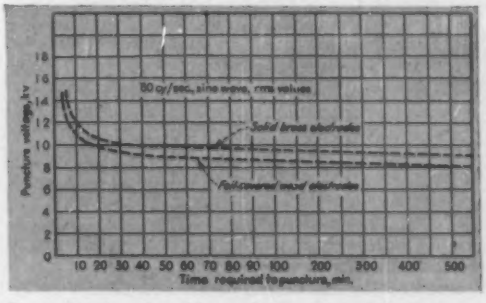
60 cy/sec, sine wave, rms values
Solid brass electrodes
Foil-covered wood electrodes
Puncture voltage, kv
Time required to puncture, min.

Fig. 6—Relative effect of heat radiation (time required to puncture) on puncture voltage in thin flat phenolic resin laminates.

gether within the insulation body. When voltage is rising in the cycle, charging current to the condensers flows through the minute high resistances and on the other half cycle the flow is reversed. The time taken for the current to fully charge the condensers depends on the value of the resistance, and is a measure of the dielectric quality. Increased insulation temperatures apparently raise the magnitude of the many resistances, thereby requiring more time for charging the capacity of the insulation, thus increasing dielectric hysteresis losses by increasing the phase displacement between current and voltage.

Up to recommended working temperatures, the approximate relationship between dielectric absorption and temperature for laminates is shown in Fig. 7. The value of dielectric absorption is termed "insulation power factor", and is measured by the difference between the 90 degree phase angle for a perfect insulator and the actual phase angle. Thus the higher the power factor, the greater the absorption losses. As the quantity of charging current depends on an insulator's electrical density or "dielectric constant", the loss for any insulator is the product of insulation power factor and dielectric constant.

EFFECT OF MOISTURE ON DIELECTRIC ABSORPTION. The combination of current loss through absorbed moisture with the displacement current in phase, results in a larger portion of circuit energy being transformed into heat; thus, the apparent power factor of the insulation has increased. Actually the absorption currents are probably only slightly increased because absorbed moisture may break up into pockets of occluded gas, adding to the non-homogeneous structure; the majority of the observed losses are I^2R type, particularly at high working gradients.

Some loss factor values for laminated plastic insulations are given in Table I. For the reasons given previously, these should be used in design at non-critical gradients only.

VOLTAGE GRADIENT AND DIELECTRIC ABSORPTION. Since the energy in the dielectric current is proportional to the potential and the current, for good insulation dielectric absorption losses should increase approximately as the square of the voltage. Fig. 8 well established data, indicates that the losses in this relationship are usually even larger than the square value, because of increasing chain lineup of conducting particles and breakdown of imperfections. Absorption losses for solid insulation must be considered at less than elastic limits; any overstress changes the values radically, because of permanent damages.

Dielectric constant and insulation power factor should remain constant at any voltage gradient up to the electric elastic limit. Actually, however, they show an increase in power factor and decrease in dielectric constant at high stresses. This is probably caused by minute local breakdowns in wet fibers and gas bubbles, in turn allowing higher energy absorption by heating while still within the elastic limits.

DIELECTRIC ABSORPTION AND FREQUENCY. Dielectric absorption loss per cycle remains approximately constant at commercial frequencies; therefore, absorption increases directly with increasing frequency as more losses occur in any given time. As frequency increases, additional losses also occur because of faster heat accumulation, reducing the dielectric elasticity, and as capacity reactance allows larger displacement currents for a given potential, more energy is absorbed, still further increasing temperatures. Fig. 9 illustrates the loss-frequency relation from test data at high (not radio) frequencies.

Table I—Effect of Moisture on Dielectric Losses
(Phenolic resin bonded, thin flat sections)

[Loss Factor = Insul. Power Factor × Diel. Constant]

NEMA Grade	Description	Loss Factor (25 C Temp.), 1,000 kc/sec (sine wave)	
		Normal	After 24 hr. Immersion
C	Gen. Purpose Cloth Base	0.276	0.516
LE	Elect. Purpose Cloth Base	0.225	0.275
X	Gen. Purpose Paper Base	0.267	0.312
XXP	Elect. Punching Paper Base	0.187	0.213
XXX	Elect. Purpose Paper Base	0.170	0.205

Insulation Resistance

At normal design gradients, the actual insulation resistance of plastic laminates are high when the insulation is in good condition, with no previous local over-stresses — in the order of several million ohms per cu cm. Since surface leakage is part of

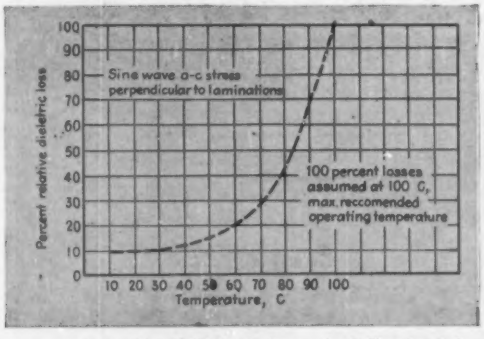
Percent relative dielectric loss
Sine wave a-c stress perpendicular to laminations
100 percent losses assumed at 100 C, max. reccomended operating temperature
Temperature, C

Fig. 7—Relationship of dielectric losses (including insulation resistance current) to insulation temp. in thin phenolic laminates.

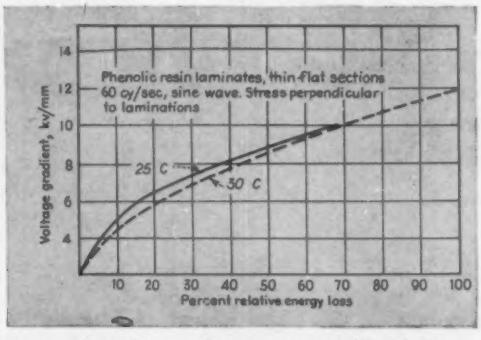
Voltage gradient, kv/mm
Phenolic resin laminates, thin-flat sections 60 cy/sec, sine wave. Stress perpendicular to laminations
25 C
30 C
Percent relative energy loss

Fig. 8—Relationship of voltage gradient and dielectric absorption losses in thin laminates, at two insulation temperatures.

any insulation resistance consideration, and actual leakages are mostly through surface films, controlled laboratory insulation resistance tests have small value in practice.

EFFECT OF VOLTAGE GRADIENT. At gradients less than critical, the energy loss from the circuit through and around the insulator will be directly proportional to the voltage, assuming little change in temperature and absorbed moisture. As the gradient is increased, but still much lower than critical, there is a tendency for local overstress because of wet fibers and surface film acting as partially conducting electrodes, or surface moisture and dirt film. At this value, the losses show a sharp increase, somewhat similar to the loss-voltage curves for corona in air. A small potential increase then causes local progressive breakdowns, the insulation resistance becoming very small as carbonized tracks are formed.

EFFECT OF ABSORBED MOISTURE. Internally absorbed moisture often does not have as marked effect on the insulation resistance as expected. Most moisture failures appear as surface breakdowns and were not initially insulator failures, at least not until carbonized paths are formed. When laminates are machined the surfaces are very porous for a minute depth, holding condensed moisture, which offers low resistance paths to the applied voltage. For critical insulation, such machined surfaces should be treated with a sealer. Fig. 10 illustrates the relative effects of moisture and voltage on insulation resistance.

FREQUENCY OF VOLTAGE. At commercial power frequencies, the energy loss by insulation leakage can represent a large portion of the total energy loss, since the true hysteresis losses are small. As operating frequency increases, the portion of loss energy through leakage becomes less significant, and at radio frequencies, it is nearly complete masked. However, high stresses warrant every precaution to reduce the leakage to minimum values.

Table II—Electrical Properties of Commercial Plastic Laminates.

NEMA Grade	General Description	Puncture gradient 60 cycle sine wave short time volts/mil		Loss Factor, Avg. 1000 kc sine wave		Tensile Strength psi Avg.	Flexural Strength psi Avg.
		Perp. to Lamin. Avg.	Parallel to Lamin. Avg.	Dry	24 hr in Water		
C	High Strength Cloth Base Elect. Grade	430	48	0.276	0.516	10,000	20,000
CE	High Strength Cloth Base Fine Weave Elect. Grade	560	55	0.234	0.288	11,000	19,600
L	Fine Weave Cloth Base	570	53	0.225	0.319	11,000	18,000
LE	Fine Weave Cloth Base	570	53	0.225	0.275	12,000	20,000
P	Punching Grade Paper Base	900	v. low	0.223	0.276	17,000	16,000
X	Gen. Purpose Paper Base Elect. Grade	800	58	0.267	0.312	21,000	18,000
XX	Punching Paper Base	900	63	0.187	0.213	18,000	14,000
XXX	Elect. Grade Paper Base Elect. Grade Best	850	76	0.170	0.205	11,000	18,000
XXXP	Punching Paper Base	900	60	0.129	0.158	15,000	16,000
AA	Asbestos Cloth Urea Resin	78	10	4.42	9.12	8,000	16,000
G5	Med. Glass Cloth Base Urea Resin	445	34	0.067	0.703	37,000	45,000
G5	Fine Glass Cloth Base Phen. Resin	500	30	0.098	0.181	30,000	45,000
G3	Med. Glass Cloth Base Phen. Resin	510	45	0.082	0.77	24,000	30,000
G3	Fine Glass Cloth Base Phen. Resin	880	52	0.072	0.194	15,000	24,000
G1	Coarse Glass Cloth Base	520	55	0.082	1.02	11,000	18,000

Table II lists common electrical properties for commercial laminated plastics that are used as a design basis. Before a good insulator design can be determined, it is important to know the exact type of dielectric stress that will occur—duration and amplitude of impulses, d-c or a-c. From these facts, as well as peak voltage gradient and frequency, the insulation size can be decided on the basis of advertised dielectric strength, reduced by a 10 to 30 percent safety factor.

A safety factor based on the actual operating temperature (maximum), must be found and applied to determine the safe working gradient, since heat increase also increases losses and reduces puncture strength.

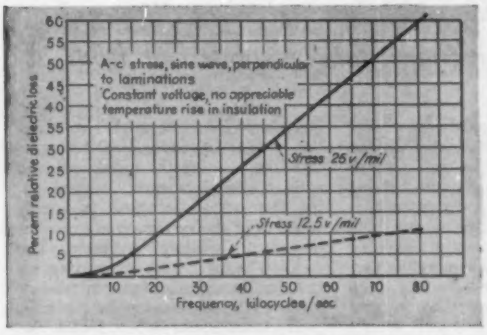
A-c stress, sine wave, perpendicular to laminations
Constant voltage, no appreciable temperature rise in insulation
Stress 25 v/mil
Stress 12.5 v/mil
Percent relative dielectric loss
Frequency, kilocycles/sec.

Fig. 9—Relationship between dielectric absorption and frequency of stress in thin flat sections of phenolic resin laminates.

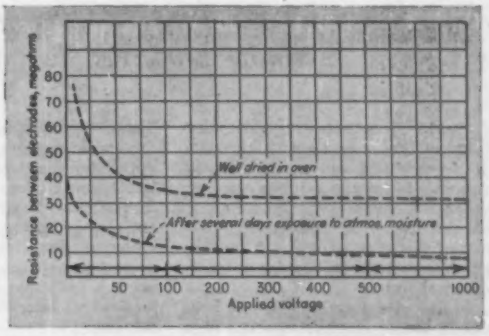
Well dried in oven
After several days exposure to atmos. moisture
Resistance between electrodes, megohms
Applied voltage

Fig. 10—Effect of absorbed moisture on insulation resistance in thin sections of phenolic resin laminates, using d-c stress.

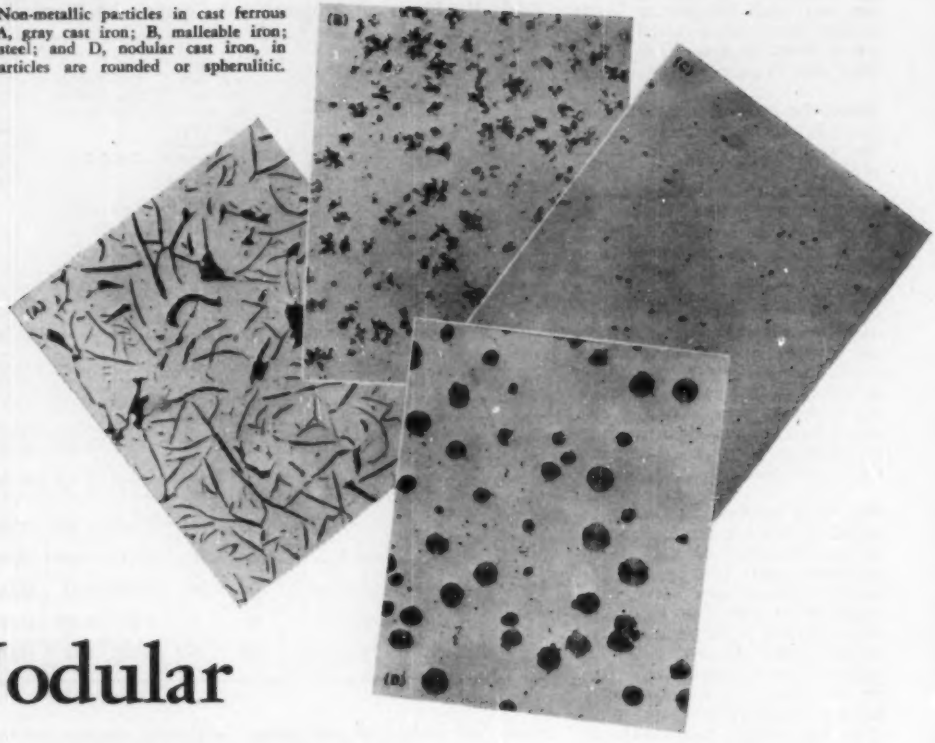

Fig. 1—Non-metallic particles in cast ferrous metals: A, gray cast iron; B, malleable iron; C, cast steel; and D, nodular cast iron, in which particles are rounded or spherulitic.

Nodular Graphite Cast Iron

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A new ferrous casting alloy which has higher ductility and tensile properties than ordinary flake graphite cast irons.

GREATLY IMPROVED STRENGTH, ductility and toughness are characteristic of the new cast iron which is known variously as nodular graphite cast iron, spheroidal graphite cast iron or ductile cast iron. The distinguishing feature of this material is that it contains graphite particles in nodular or nearly spherical form.

In the usual form of gray cast iron, free carbon or graphite separates from the melt just before or during freezing, in the form of flakes or plates. These thin sharp-edged flakes reduce the tensile strength and especially the ductility of the steel-like matrix. Malleable iron is also a graphite bearing ferrous alloy, however, the graphite is not formed during freezing, but by a subsequent heat treatment of solidified white iron castings. The graphite particles in malleable iron are in a more rounded nodular form than in gray cast iron.

Nodular cast iron is produced by adding cerium or magnesium in the ladle to molten iron with a composition similar to conventional soft gray cast iron, causing the metal to freeze with an altered structure. A graphitizing ferro-silicon inoculant is usually added after the cerium or magnesium, to control "chilling" tendency. The addition is not merely an alloying effect, but causes a fundamental change in the shape of the graphite particles.

The micrographs in Fig. 1 show the non-metallic particles in each of the four ferrous foundry metals. If these

particles are visualized three-dimensionally it is readily seen how the shape of the non-metallic components affects mechanical properties. In gray cast iron the steel-like matrix is riddled by sharp-edged, stress-raising flakes. In malleable iron the graphite content is lower and the shape of the particles less disruptive of the matrix. Cast steel contains a very small proportion of non-metallic inclusions which affect the matrix only slightly. Nodular cast iron has about the same amount of graphite as flake graphite

Table I—Composition of Two Types of Nodular Iron (As Cast)

Element	High Tensile percent	High Ductility percent
C	3.40	3.50
Si	2.50	2.60
Mn	0.70	0.15
P	0.14	0.025
S	0.015	0.015
Mg	0.06	0.06

From paper by Vennerholm, Bogart and Melmoth (see References)

cast iron but the particles are spherulitic and consequently have much less weakening and embrittling effect. On the other hand, the high damping qualities and high resistance to heat checking, typical of cast irons containing large flake graphite, will be adversely affected by a smooth, rounded, spherulitic graphite particle.

Properties of nodular iron castings can be varied widely by changing relative compositions of the various constituents. If the emphasis is on high tensile strength with ductility as a secondary factor, a conventional cupola iron can be treated to produce an iron of composition shown on the left in Table I. The microstructure of such an iron, Fig. 2, is composed of a lamellar pearlitic matrix with spherulites interspersed. Should the emphasis, however, be on high ductility and resistance to impact (as cast properties), a composition of the type shown at the right in Table I should be considered. The microstructure of such an iron, shown in Fig. 2, is composed of a lamellar pearlitic matrix with large "bull's eye" ferrite surrounding each spherulite. In addition to these two, many other compositions of nodular iron are made.

Manganese adversely affects the ductility and should, therefore, be kept as low as economic considerations permit, preferably around 0.15 percent, and not over 0.30 percent. Phosphorus has a pronounced embrittling effect and must not exceed 0.04 percent for maximum ductility and impact. Although high silicon and high carbon are desirable in that they promote ferrite precipitation and consequently produce irons of maximum ductility, silicon in excess of 3 percent begins to harden the ferrite, with resultant decrease in ductility. Similarly, high carbon contents tend to produce more and usually larger nodules and as a result may decrease strength, ductility and modulus of elasticity slightly.

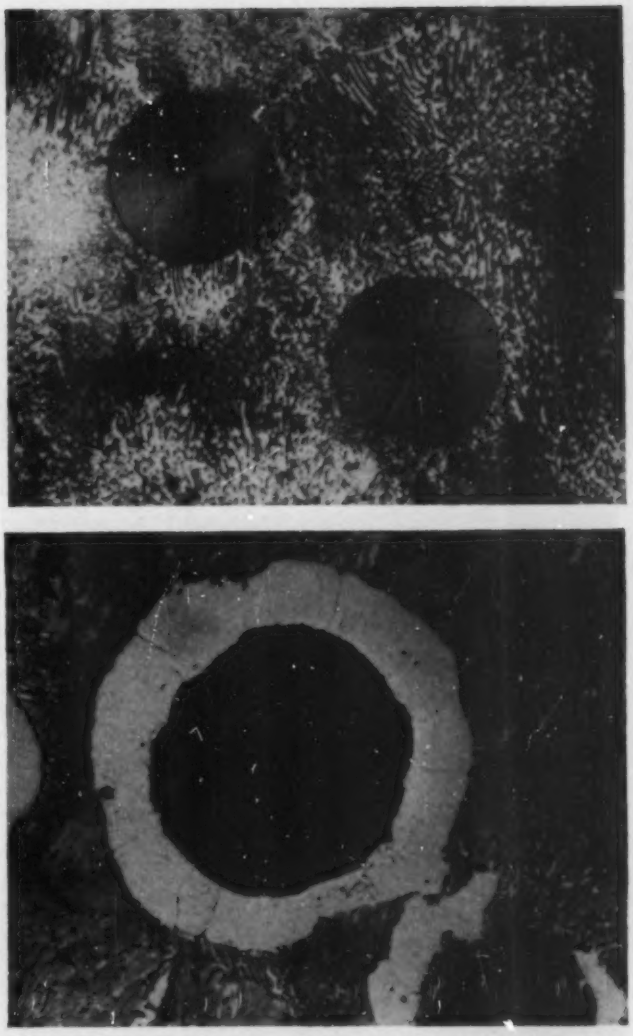

Fig. 2—Microstructures of two types of nodular iron: Top, high tensile type has a lamellar pearlitic matrix with spherulites interspersed; bottom, high ductility type has a lamellar pearlitic matrix with large "bull's eye" ferrite surrounding each spherulite. (From paper by Vennerholm, Bogart and Melmoth—see References).

Properties

Properties of nodular irons are compared with a group of other cast ferrous alloys in Table II. Values given for the nodular irons are based on the compositions shown in Table I; however, as will be shown in the following discussion, a much broader range of physicals is possible.

TENSILE PROPERTIES. Bars machined from about one-inch section coupons from keel block castings are generally used for cast steels because they give shrinkage-free test specimens. Tested on this basis, tensile values for nodular

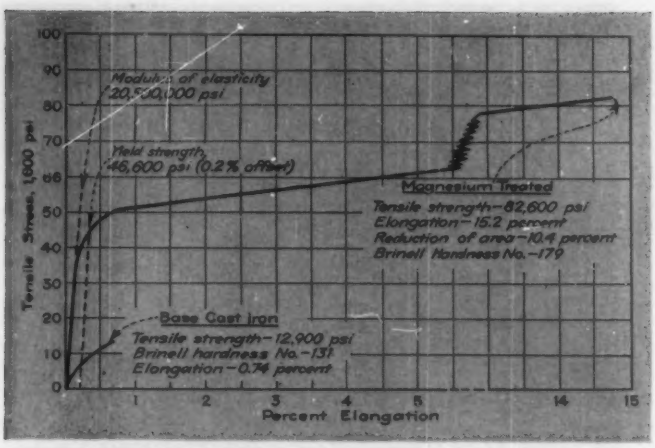

Fig. 3—Tensile stress-strain curves for cast magnesium treated nodular iron and the same base iron, untreated, show the large increase in tensile strength and ductility.

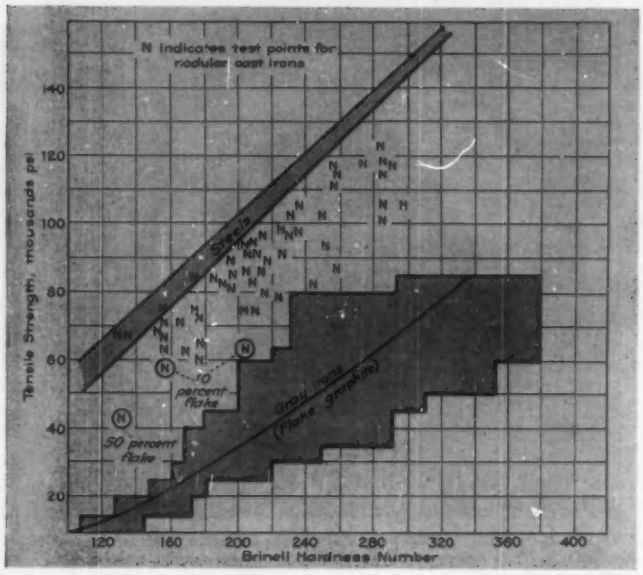

Fig. 4—Tensile-Brinell relationships (sometimes a quality criterion) for cast steels, gray irons, and nodular irons show usefulness of nodular irons in "in-between" region.

cast irons are within these ranges:

Property	As Cast	Annealed
Tensile Strength, 1000 psi	75–120	65–75
Yield Strength, 1000 psi	50–85	45–55
Elongation, percent	1–15	15–25
Reduction of Area, percent	1–15	15–25

In the as-cast state, tensile properties vary within these limits, depending on base iron composition, magnesium (or cerium) content and additional alloy content, if any. A simple annealing treatment, heating to above the critical temperature and slow cooling, breaks down the combined carbon to give a ferritic matrix. In this condition tensile properties are less variable.

These properties are superior to those of gray iron. Strength levels are generally higher than for malleable irons and the annealed ductility about the same. Tensile properties of nodular iron are only slightly below those of ordinary cast carbon steel.

Tensile stress-strain curves taken from two test specimens cast from the same heat of high carbon iron are shown in Fig. 3. One specimen was cast from a ladle treated with a cerium-magnesium alloy and ferrosilicon inoculant to produce nodular graphite iron. The other specimen was cast from untreated iron. The base composition is too high in carbon (total C, 3.84 percent) to give properties representative of an engineering grade of flake graphite iron, but it does illustrate the improvement caused by changing the graphite particle shape. Since the nodular iron does not show a definite yield point, yield strength is obtained by the 0.2 percent offset method. Elastic moduli in nodular irons are usually 20 to 25 million psi; this is determined by the slope of the straight portion of the curve.

IMPACT STRENGTH. Cast irons are not usually tested by the same methods used for tougher metals. However, a few tests on gray irons and nodular irons have been made, using the Charpy V-notch specimen and standard pendulum impact procedure. Two typical nodular irons gave 5 and 6 ft-lb Charpy impact in the as-cast state, and 10 and 11 ft-lb after annealing. Ordinary grades of flake graphite irons gave less than one ft-lb. Some malleable irons gave approximately the same results as the annealed nodular iron—in the order of 10 ft-lb. Cast steels give considerably higher values —in the order of 25 ft-lb for annealed medium carbon steels. Thus, nodular graphite cast iron is considerably tougher than gray cast iron but more brittle than cast steel of comparable tensile strength.

HARDNESS. The magnesium or cerium treatment to nodulize gray iron causes an increase in Brinell hardness number chiefly because, unlike flake graphite, the spherical graphite particles do not slip under the Brinell ball. However, the actual hardness of the matrix, as determined in micro-hardness tests, is usually not increased by the nodulizing treatment and machineability is not impaired. Nodular irons in the as-cast state are usually 200 Brinell or more, annealing may reduce this to about 150 Brinell. Nodular irons can be hardened by quenching or flame hardening.

The correlation between Brinell hardness and tensile strength for steel is close enough that tables are often given to allow prediction of tensile strength from hardness readings. For gray cast irons, however, the tensile, Brinell relation is much less direct,

Table II—Comparison of Cast Ferrous Alloys

Characteristic	ALLOY IRON						NODULAR IRON		
	Gray Iron SAE 111	Ni, 0.80 Cr, 0.20 Mo, 1.00	Malleable SAE 35018	Pearlitic Malleable SAE 43010	Steel SAE 0030	Steel SAE 0105	High Tensile (As Cast)	High Ductility (As Cast)	High Ductility (Annealed)
Yield point, psi			35,000	43,000	35,000	85,000	80,000	55,000	45,000
Tensile strength, psi	30,000	70,000	53,000	60,000	65,000	105,000	100,000	80,000	65,000
Elongation, percent			18	10	24	17	1.5	10	16
Reduction of area, percent					35	35	1.0	8	20
Brinell hardness number	190	286	130	170	130	217	255	190	160
Modulus of Elasticity, psi	$19x10^6$	$21x10^6$	$25x10^6$	$25x10^6$	$30x10^6$	$30x10^6$	$24x10^6$	$24x10^6$	$24x10^6$
Impact strength, 0.798 in. dia. bar, ft-lb	10	20					40	180	260
Heat treatment	None	None	Anneal	Anneal	Anneal	Quench & Temper	None	None	Anneal
Present cost (including conversion and heat treating), dollars per ton of castings	47.56	77.93	64.00	65.13	72.68	96.67	67.35	72.51	78.51

From paper by Vennerholm, Bogart and Molmoth (see References)

but there is a tendency for strength to increase with increasing hardness, as shown in a statistical study of 1553 tests (J. T. MacKenzie, *Proc. A.S.T.M.*, Vol. 46 1946, pp. 1025-1038. For nodular irons the tensile-Brinell ratio is much closer to that for steel than for gray iron. Fig. 4 shows a tensile-Brinell chart with the approximate ranges for steels and gray cast irons indicated, and several individual test results on nodular irons plotted in. Where an iron is incompletely nodular as indicated, the tensile-Brinell ratio is lowered toward the range of flake graphite irons.

COMPRESSIVE STRENGTH. The compressive strength of flake graphite irons is approximately three times the tensile strength and varies directly with Brinell hardness. Some tests on nodular irons have shown that the compressive strength (in contrast to tensile strength) is not significantly greater than the compressive strength of a flake graphite iron of comparable hardness. Nodular iron is more like steel in that its useful compressive strength is not significantly higher than its tensile strength. Where gray iron is used primarily for its compressive strength, there is no significant advantage in replacing it with nodular iron.

FATIGUE PROPERTIES. The ratio of endurance limit to tensile strength of ferrous metals is fairly constant, usually between 0.4 and 0.5. Nodular iron is no exception to this, fatigue tests have shown the endurance limit of nodular irons to be between 40 and 50 percent of the tensile strength. Thus nodular iron can be expected to be better than gray iron in fatigue properties by the same percentage that it is higher in tensile strength.

WEAR RESISTANCE. The resistance of nodular irons to lubricated wear is excellent, particularly in the absence of any free ferrite, and compares very well with gray cast iron. The nature of the graphite formation leads to the assumption that the resistance to heat checking is lower in nodular iron than in cast iron, and consequently that the resistance to dry wear will be lower. Some data has appeared in the literature which tends to substantiate this.

Effect of Section Size

Nodular cast irons are more susceptible to "chill" (differential freezing) in light sections than is the base gray iron composition. It is difficult to avoid chilling in sections less than 3/16 in., unless a high silicon iron is used, with the resultant detrimental effect on physical and other properties. The effect of section size on the uniformity of physical properties is not noticeable in cross sections up to about 4 in. Above this thickness, however, the ductility falls off rapidly at first, but at a decreasing rate as the section size is further increased. This is true not only in the as-cast but also in the heat treated condition.

This "mass effect" is related to the amount of magnesium in the section. An examination of the microstruc-

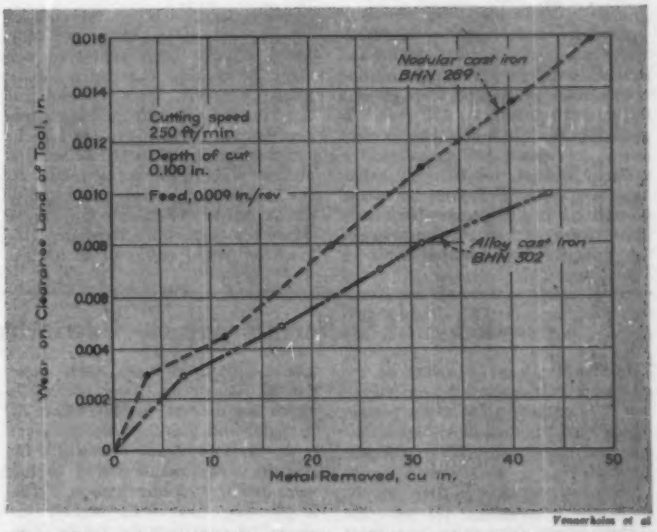

Fig. 5—Comparative machinability of nodular and alloy cast iron. Nodular iron appears to have better machinability than ordinary flake graphite iron of similar hardness.

Fig. 6—This bursting failure can be avoided by casting pipe fitting of nodular iron.

tures shows that the loss in properties in the heavier sections is, to a large extent, a result of insufficient amounts of magnesium. Also, the higher manganese content of the high tensile nodular iron appears to augment the magnesium. The selection of the proper amount of magnesium for a given size casting, therefore, must be based on the average casting size, to obtain maximum nodular graphite in heavy sections without inducing excessive chill in the lightest section of the same casting.

Heat Treatment

Nodular irons respond to heat treatment in a manner similar to gray and malleable cast irons. A high ductility formulation of nodular iron given a two-hour treatment at 1,320 F and air cooled, produced an iron with an elongation of about 17 percent and a Brinell hardness of 163. A longer treatment, 1,750 F for two hours and furnace cooling at a controlled rate to 1,200 F, resulted in an elongation of 19 percent and 148 Brinell hardness.

Nodular irons respond well to hardening treatments, either local or full. By oil quenching from 1,550 F and tempering, improved tensile strength of both the high tensile and high ductility types are obtained. This treatment results in improved ductility of the high tensile type (compared with as-cast), and in higher Brinell hardness but reduced ductility of the high ductility type.

There is some evidence that nodular irons can be hot worked around 1,750 F with good results.

MACHINABILITY. When materials of similar physical properties are compared, nodular irons appear to machine better than conventional flake irons. However, since conventional cast irons are generally used in a hardness range of about 167 to 248 Brinell, compared with 228 to 300 Brinell for nodular irons in the as-cast condition, any statement regarding machinability can be easily misunderstood. Fig. 5 shows comparative machinability data based on partial results of an investigation on nodular cast iron being carried out at the Ford Motor Company.

Applications

Nodular cast iron appears to fill the gap between flake graphite gray iron and steel. For cast iron parts, where simply an increase in strength is desired, nodular iron of the high tensile type (Table I) is a logical answer. Fig. 6 shows a 24 in. gray iron pipe fitting after a bursting test. By casting this part in nodular iron the bursting strength was increased to a value two to three times that obtained with the regular gray iron fitting. In addition to a property advantage over gray irons, nodular irons have an economic advantage over alloy irons (see Table II). There appears to be no immediate economic advantage in replacing malleable iron castings with nodular iron, but it may be used in the malleable field for section sizes larger than those possible in malleable iron at present.

Parts which have been made of nodular cast iron include: Crankshafts, flywheels, agricultural implement parts, car wheels, valves, pipe fittings, pipe, and rolls. Nodular iron may replace steel castings where better castability and machinability are the deciding factors. Nodular iron castings compare quite favorably with steel castings for component parts of engines and compressors. The Ford Motor Company is testing the suitability of nodular iron as a replacement for cast graphitic steel (1.0 and 1.50 percent C) in the manufacture of crankshafts.

Indications are that research in this country and abroad will permit nodular irons to become much more economically competitive with other ferrous casting alloys.

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Knowledge of Spectrum Greatly Expanded in Last 50 Years

THE SPECTACULAR ADVANCES of the electronic half-century can be visualized by comparing the small portion of the spectrum used in 1900 with the comparatively large portion now utilized.

Fifty years ago, the parts of the spectrum in extensive use were the electric power frequencies and those of carbon filament and arc lamps. The modern spectrum starts with these power frequencies, large segments which are used in various forms of induction and dielectric heating. Next is the infrared section represented by heat from the sun, followed by the much-explored visible portion. The neighboring ultra-violet section includes the rays from the sun or from man-made sources. Then comes the wide range of X-ray frequencies useful for fluoroscopic examination.

Gamma rays represent energy radiated by atomic disturbances from radioactive materials, a field only recently given its due prominence. Finally, cosmic rays present the greatest mystery and are known only by measurements made on radiations from inter-stellar space.

How Metals Fracture

Foreign abstract from "The Fracture of Metals" by C. F. Tipper, *Metallurgia* (British), January 1949.

MOST DANGEROUS FRACTURES in engineering service are those occurring unexpectedly in a material which is ductile by ordinary standards and might therefore be expected to deform plastically rather than break at points of high-stress concentration. Fracture by fatigue is an example of such a failure. Another is the so-called brittle fracture of iron and mild steel, particularly at low temperatures, which has been known and has received spasmodic investigation on several occasions, without any rational explanation being found. This type of brittleness has reently come to the fore as a result of spectacular fractures in certain all-welded ships.

There are three ways in which fracture is known to take place in metal crystals:

1. The fracture plane may be crystallographically the same as the plane of shear. The angle which this plane makes with the direction of the principal tensile stress is generally between 40 and 50 deg. but depends upon the orientation of the crystal and the amount of deformation before fracture.

2. There is no well-defined plane, but a wedge is formed by two shear planes making equal angles with the direction of the principal tensile stress, or, if more planes participate, the crystal may draw down almost to a point.

3. The fracture plane may be crystallographically different from possible glide planes.

The chief difference between 1 and 3 is in the amount of distortion which takes place during the actual partition. Thus, the fracture plane may be roughened and have a matt surface or appear bright and polished. If the latter, as is generally the case in 3, the fracture is described as cleavage.

It has been known for a long time that a tendency towards cleavage fracture in a iron increases as the temperature falls. The change in commercial steels may be gradual or sudden. Even if there is a range of 40 C, the change in mechanical properties as measured by rise in yield and ultimate stresses only amounts to a few percent, and there is no measurable decrease in ductility. Hence, an increase in resistance to shear due to fall in temperature does not of itself appear sufficient to account for the change observed, and in fact, neighboring crystals in the same section are observed to fracture or deform.

Not only does the temperature decide whether a crystal shall deform by shear or fracture, but the orientation of the grains in a poly-crystalline aggregate relative to the tensile stress and to each other may also be a determining factor.

The appearance of the fracture of the poly-crystalline aggregate reflects the mode of fracture of the individual grains. The fracture may be wholly made up of types 1 and 2, when the appearance is silky or fibrous, or a certain proportion of the grains may crack and break with little or no distortion. Thus both forms of fracture occur in the same sample. The proportion of each type in a fracture determines the energy absorbed in its propagation as well as the velocity of propagation. The change in fracture does not always follow the energy absorbed in impact, as often a large proportion of the total recorded in such tests is absorbed before fracture begins. Where the measurements of the energy to propagate a fracture have been made, there is a close relation to the type of fracture.

Although most of the cracks appear in the ferrite, numerous examples of their running through adjacent pearlite have been encountered. Groups of ferrite grains frequently have very similar orientations. This is evident from the indictness of the intervening boundaries and fractures may be seen to run across such groups with little change of direction. If such zones are favorably placed for the development of cleavage fractures they may contribute towards the easy initiation of such fractures and a heat-treatment which tends to produce groups of similarly orientated ferrite grains is clearly undesirable. A few isolated grains or groups of grains breaking in a brittle manner are often visible in an otherwise typically fibrous fracture.

Most service fractures have been traced back to some sort of notch. Fractures made in the laboratory have been started by the introduction of a notch perpendicular to the applied stress. The metal at the base of the notch yields at a mean stress, which agrees with that predicted from measurements of the stress concentration factor determined in an exactly similar test piece of cast polyester resin by photo-elastic means. Whatever the type of fracture there is always a plastic zone at the notch bottom, and in a normal fibrous fracture, it propagates at the mean breaking stress of the unnotched tensile test piece.

Thus, the metal at the base of the notch can be regarded as passing through all the stages that a test-piece of very short gage length would pass through from yield to fracture. The machined notch ensures that the mean path of the natural crack is at 90 deg to the direction of loading. A notch at 45 deg does not lead to a brittle fracture under the same conditions of test. As soon as the natural crack has formed, the shape of the original notch loses significance. A notch also ensures a relatively high rate of strain even under static loading, and this increases when the natural crack with its small radius at the end is formed. Although cleavage cracks form under static loads, they are more readily produced under impact.

Fracture is first visible in the center of the notch bottom often by the opening of a crack along a line of inclusions. The main fracture front is thus always ahead of fracture of the surfaces of a plate, to an extent which varies with the material, the thickness of the plate and temperature of test. This shape persists at distances far removed from the original notch. There is nothing essentially different from the sequence of fracture in a round bar in tension shown to start in the center. Although in the round bar it is very difficult to arrest the fracture at different stages, these stages can be studied in reverse order in the same specimen by cutting sections through an arrested fracture in a plate.

The ends of less brittle and fibrous fractures, and sections through numerous brittle fractures, have also been investigated. In front of the advancing crack on the surface is a zone plastically deformed which is very small in brittle fractures, but may be spread

over the whole plate in the most ductile. Sections through this zone enable the depth to which the center has broken to be determined. The outline of the separated parts is irregular and finally consists of holes separated by unbroken metal. Some of the holes are formed by the cracking of a crystal or a group of crystals and their separation by subsequent deformation of the unbroken metal. Thus, on the fractured surface, troughs alternate with ridges, giving rise to the chevron pattern so characteristic of many of these fractures.

While the fracture of ductile material cannot be explained in quite the same way, separation along lines of inclusions can also divide the section into groups of crystals, each one of which may be regarded as a separate tensile test-piece which can deform by shear far easier when freed from transverse restraint. In both types, the holes are finally joined by fine cracks and the fracture is complete.

The influence of structure on mechanical properties, apart from composition is shown by the lower values for elongation and especially, reduction in area in a tensile test and the energy absorbed in impact tests when the test-pieces are cut across the direction of rolling. Since inclusions are elongated by the working they are more dangerous when they are placed with their long axes perpendicular to the principal tensile stress. In this position also, there are more "ways through" for the advancing fracture of whatever type. Cracks meeting an inclusion or hole may be diverted or stopped if the discontinuity affords relief of stress.

These observations refer chiefly to the fracture of mild steel, but they can be applied to explain the fracture of all poly-crystalline aggregates.

No-Pressure Molding of Phenolic-Asbestos

Foreign abstract from "No-Pressure Molding" by L. N. Phillips, Aircraft Production (London) p 370, November 1949.

ONE OF THE BIGGEST OBSTACLES to the use of high-strength reinforced plastics as engineering materials has been the pressure required to make moldings with satisfactory strength properties. This consideration has been particularly important in the aircraft and ship-building fields, where a molding process such as would produce a smooth rivetless contour holds very great promise. For instance, it is theoretically possible to mold a complete aircraft wing in a huge steel mold with an enormous hydraulic press by normal high-pressure methods (about 2,000 psi). However, in view of the high cost of the equipment, such a process would not appeal to industry.

It is well to examine the reasons why such pressures are required. The resins normally used, such as the phenolformaldehyde and ureaformaldehyde types, cure by a process of chemical condensation with the elimination of a considerable quantity of water. Thus, the condensation of the resin is advanced as far as possible before putting the impregnated material into the mold, so as to reduce the liberated water to a minimum. The resin, however, now flows only with difficulty and considerable pressure is needed to force the plastic particles into the details of the mold cavity. The high pressure used in the molding cycle serves to consolidate the loose reinforcement into a dense material, to reproduce the mold impression of surface finish accurately, to enable the resin to flow and to resist the steam pressure tending to blister the molding.

VACUUM TECHNIQUE. To avoid the difficulties inherent in the high pressure process, the Royal Aircraft Establishment of England developed a vacuum molding process. It applies particularly to phenolic and other resins which cure by chemical condensation. When molding with vacuum it is found that, since the felts become soft and plastic on warming, little pressure is needed to weld them together and to press them firmly against the mold. A main function of the vacuum is continuously to remove water of condensation and other volatiles produced in molding.

It is necessary in this technique, to avoid any small spots which do not vent freely to the outside, so a thick, flexible porous pad is placed between the molding and the vacuum bag. A condenser of adequate capacity is needed on the vacuum pump to trap the large amount of volatiles evolved during cure. When the process is carried out properly a product is obtained with specific properties equal to those of the high-pressure product.

NO-PRESSURE TECHNIQUE. It has now been found possible to dispense with the vacuum pressure. The only requirements are that the phenolic-asbestos laminate felt be brought into close contact with each other and the mold and that it be vented freely to the atmosphere.

The no-pressure technique is based upon five simple principles which are listed below:

1. It is necessary to soften the felts without using excessive heat, in order to manipulate the material easily during the laying-up process. This is most easily done by applying warm water to the felts.

2. Consolidation of the felts should be in two stages. The first should be with a smooth narrow roller, in order to apply local pressure. The second pressure is with a wide rubber squeegee to even out local variations in thickness and to enable the water vapour to escape evenly over the whole surface.

3. If two felts of phenolic-asbestos are pressed together and cured without pressure, the adhesion between them is found to be poor. It is necessary to improve the adhesion by putting a suitable adhesive between successive felts.

4. Some means of internal restraint should be used in order to reduce the

Table I—Average Properties of Molded Phenolic-Asbestos Laminate

Specific Gravity	Bend "E" (psi)		Tensile "E" (psi)		Tensile Strength (psi)		Compressive Strength (psi)		Shear Strength (psi)	
	Actual	Spec.	Actual	Spec.	Actual	Spec.	Actual	Spec.	Actual	Spec.
(a) 1·08....	1·47 × 10^6	1·36 × 10^6	1·76 × 10^6	1·63 × 10^6	13,780	12,750	8,100	7,850	4,350	4,020
(b) 1·32....	2·22 × 10^6	1·68 × 10^6	2·22 × 10^6	1·68 × 10^6	18,200	13,900	13,000	9,900	5,700	4,300

(Grain direction of sheet is longitudinal throughout)
(a) Average properties, no-pressure process (b) Average properties, vacuum-bag process.

springback of the felts to their original thickness during cure. It should be added that the restraint—actually a controlled shrinkage—should act if possible throughout the thickness of each felt.

5. The vapor pressure of water is high (526 mm Hg) at 90 C, the temperature used. Therefore, some means should be found to catalyse the phenolic resin to enable the main cure to occur at a lower temperature.

The first two requirements above are easily satisfied. The last three requirements can be conveniently met by a suitable choice of adhesive.

In this case it was decided to use a resorcinol-formaldehyde glue modified with furfuryl alcohol.

STRENGTH PROPERTIES. Sample boards were cut into tensile and bending specimens and tested at room temperature by standard methods. An interesting effect was noticed in the difference between tensile and Bend E results for Young's Modulus. This is to be expected since the resin-content of the lay-up varies across the thickness of the board. The test results show that with the present method, the specific tensile strength and shear strengths of the phenolic-asbestos are over 90 percent and the specific compressive strength about 80 percent of those of the vacuum-made material. The material made by the no-pressure process has an even texture without surface roughness and takes a good finish.

Reducing Instrument Bearing Friction

Abstracted from "Oscillatory Sliding Friction (The Frictionless Bearing)" by Stephan Thyssen-Bornemisza, published in Microtechnic, Vol. 2, No. 6, 1948 and Vol. 3, No. 1, 1949.

A LARGE NUMBER OF EXPERIMENTS were carried out to determine the effect of oscillations on friction. Two types of relative motions in bearings were compared. The first was a uniform relative velocity; the second was a uniform relative velocity plus a superimposed oscillatory relative motion parallel to the uniform velocity.

In the actual experiments carried out the uniform velocity was not exactly uniform. This can be seen in Figs. 1 and 2.

The net loss of energy by the beam under both uniform and oscillatory relative velocities are shown in Fig. 3. They are measured by a so-called coefficient of friction which bears the same relationship to net energy loss as the coefficient of friction bears to energy loss. The coefficient of friction of 0.0005 is considered very impressive by the author.

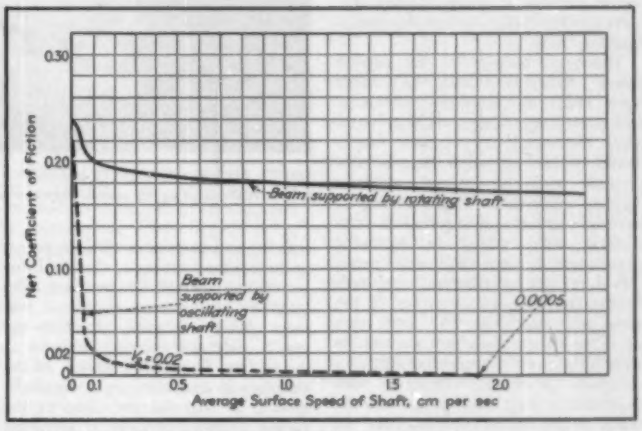


Fig. 3—The net frictional forces retarding the motion of the beam are substantially reduced by oscillating the shaft supporting the beam, as can be seen from chart.

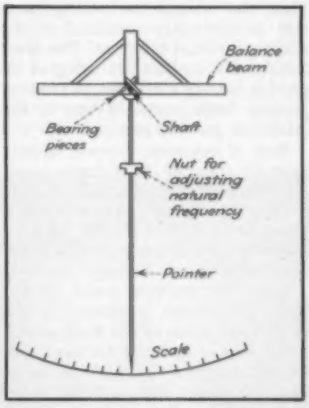


Fig. 1—The balance beam is supported by two pairs of bearing pieces resting on the shaft. Loading weights can be placed on the balance beam or suspended from hooks in light pans. The natural frequency of the beam can be changed by adjusting the nut on the pointer. Using the apparatus of Fig. 2, the shaft can be rotated or oscillated about its longitudinal axis.

The basic principles of operation of oscillatory sliding friction are easily understood. When the oscillatory velocity is considerably higher than the uniform velocity, the relative motion of the bearing surfaces changes direction twice during each cycle of oscillation. As a result the frictional forces tend to increase the uniform relative velocity during part of the cycle and also tend to decrease the uniform relative velocity the remainder of the cycle. However, in the case of the uniform relative velocity, the frictional forces always oppose the uniform relative motion. It is therefore to be expected that oscillatory sliding friction will not retard a uniform relative motion as much as uniform sliding friction.

Changing from uniform sliding friction to oscillatory sliding friction does not give an overall reduction in power dissipated because frictional forces are not reduced.

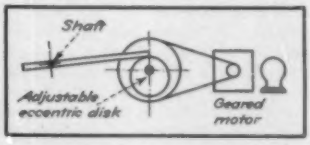


Fig. 2—The shaft is oscillated or rotated by a mechanism driven by a variable speed geared motor. The shaft is oscillated at frequencies from 2 to 40 cps. When rotation of the shaft is desired, the eccentric is replaced by a belt drive.

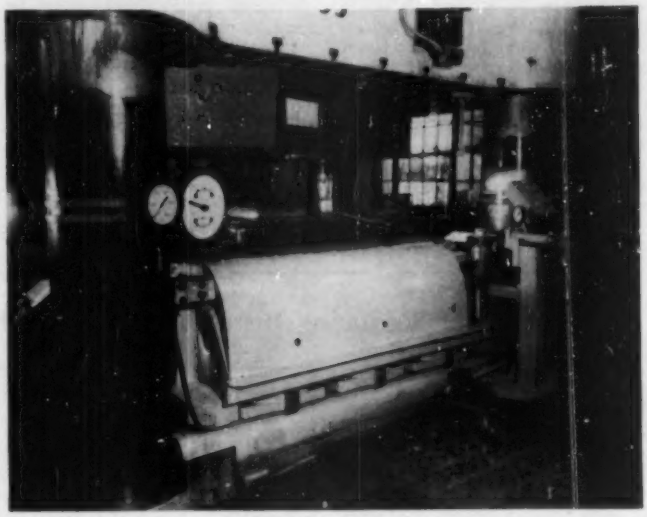
Marform Process Halves Costs Of Metal Forming

RESEARCH ENGINEERS, who developed the Glenn L. Martin Marform process for forming metal parts, state that formed sheet metal parts can now be produced with savings as high as 50 percent. To make this important technical development available to industry, the Baltimore company has accepted a proposal of Hydropress, Incorporated to build and sell the special forming units.

Thorough testing of the Martin process indicates it will: (1) Form sheet metal to compound curvatures and draw deep flanges without wrinkling the metal; (2) permit deeper draws in one operation than is now possible with conventional methods; (3) do away with finish forming of parts by hand as now required on parts formed with rubber in hydraulic presses and on some die-formed parts; (4) form several different parts, each having similar pressure curves, in the same press operation; (5) form parts of different materials and thicknesses with little or no effect on tooling; (6) maintain practically uniform wall thickness in deep draw parts from the blank to the finished formed part. In severely formed parts, a variation of more than 5 percent in material thickness is unusual; (7) not affect surface finishes of the metal, paint and plastic coatings during the forming operations; (8) distribute strains uniformly throughout the formed parts, with the result that they are relatively free of internal strain concentration; (9) reduce tooling costs for both low- and high-volume production; (10) effect economies in industries where product design changes are frequent and (11) reduce springback to a minimum.

Precision control of the forming pressure at progressive stages of the forming cycle is the principal feature responsible for the success of the Marform process.

In this process, a retainer containing rubber for the pressure forming medium is mounted on the upper platen of the press having an overhead ram. The male punch for the part to be formed is mounted on the base of the press. A template surrounds the punch and supports the blank prior to forming and cooperates with the punch to control the forming of the blank for successive stages of the operation. The template is supported so that it will move downward with respect to the punch under the forming pressure of the rubber. Downward motion of the template is controlled by a hydraulic system, so that the resistance to the rubber forming pressure is regulated in accordance with the requirements of the part to be formed.



SHEET METAL FORMING MACHINE has forming punch on lower platen and rubber cushion on upper platen. Pressure control mechanism is next to pedestal at right.

The accompanying picture shows the essential elements of the Marform process. The pressure in the rubber is generated by the ram of the press. The metal blank is placed over the punch and is supported by the punch and the template. As the pressure exerted by the rubber is increased by the descending ram, the template moves downward in a predetermined manner, so that the metal blank is formed, increment by increment, over the punch. As each successive increment of the blank is shaped, the formed portion is locked against the punch. At no time in the forming of a part with vertical walls is the blank unsupported as it is forced downward around the punch, thus precluding the formation of wrinkles.

Forming of each shape requires a characteristic pressure curve; that is, a definite relationship between the rubber pressure and the depth of form. When this relationship is determined for one part, it is reproduced for successive parts, by controlling the resistance of the template to downward motion of the press. Resistance of the template is controlled by a hydraulic mechanism and a valve that regulates the escape of fluid from the hydraulic mechanism in accordance with the motion of the upper platen of the press. Thus, the variation in forming pressure is thoroughly correlated to the stroke position of the press. The Marform unit's controls are designed to provide infinite variations in forming pressure from practically zero to the maximum pressure required.

Rate of operation depends entirely upon the speed of the hydraulic press. No attempt has yet been made to apply a Marform machine to a mechanical press, but it is believed that such an application would be successful if the press had sufficient "daylight" opening.

Since the pressure stroke in the forming operation is softened by the rubber, the punch can be made of materials such as Masonite for short runs on soft materials. Cast Kirksite can be used for longer runs or harder materials. Steel punches are generally utilized for production runs.

A flat steel pressure plate is required to provide a rest for the material. This plate must be flat and smooth, but the fit between it and the punch is unimportant except when forming very thin metal such as 0.010 or 0.020 in. thick stock. A thin Masonite overlay is

often used on the steel plate during short runs to save the cost of grinding the surface. The inside periphery of the plate, where it surrounds the punch, and the outside periphery of the plate can usually be torch cut.

Set-up time is relatively short, since the punch does not have to be matched. More than one form block can be used in one pressure plate or in separate pressure plates on the same machine. The pressure requirements and depth of stroke must, of course, be equal for all parts formed at the same time.

The rubber also exerts a lateral pressure during the forming operation. This pressure locks the metal already formed to the punch, thus preventing an accumulation of strain at the punch radius. The strain is therefore distributed uniformly over the complete surface of the piece being formed. Prevention of strain concentration at the punch radius not only enables the part to be formed deeper, but also maintains a uniform thickness.

Another important factor that enables the Marform process to form deep parts in one operation is the ability of the machine to provide an exact required pressure on the material at each desired depth of stroke. This pressure can be varied without a series of steps within minimum and maximum values. It can start low, be increased, and then drop off; it can be gradually increased from start to finish; or it can be started at a high value and then dropped gradually to a lower value.

Sheet metal parts can be made to tolerances of ± 0.002 to ± 0.005 in. Gages as thick as 0.675 in. in aluminum alloys and 0.102 in. in 1010 steel have been formed. These values are not necessarily maximum, but represent only the thickest gages formed to date. A reduction in blank area of 75 percent in one forming operation is considered normal for aluminum alloys. With these alloys, a cup depth equal to $\frac{3}{4}$ of the cup diameter is normally expected.

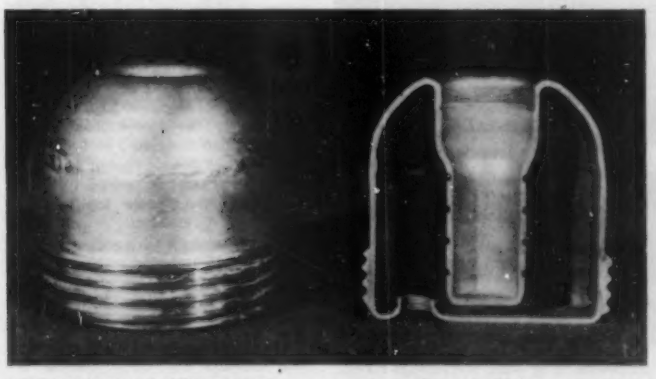
Further study is being given to a wider application of the process; development of allied tooling for secondary operations; ability to automatically and simultaneously shear material at any direction to the forming stroke; and simplification of the equipment.

Engineering Capacities Of Industrial Firms To be Indexed

NATIONAL ASSOCIATION of Engineering Companies is compiling a comprehensive index of the types of engineering services offered by engineering companies throughout the United States. Its compilation will cross-reference such services both as to categories and also geographically, so that it can serve as authoritative information to anyone seeking a source of supply for the engineering of a specific problem. The Association has contacted all reputable Ohio engineers and engineering firms known to it, supplying to them a questionnaire or check sheet on which to indicate the specialties in which they are qualified. After analyzing and tallying these Ohio results, NAEC will similarly contact other engineering concerns, state by state, during 1950.

Available registerers and directories do not perform this service. It is believed that when NAEC's indices are completed, they will be the only authoritative compilation in the field on this subject. The mechanics of the survey are handled by the Executive Secretary, Mr. A. S. Kerr, but the quality and accuracy of incoming information are evaluated by several engineers of the Detroit area, well known in industry and for their participation in the American Society of Tool Engineers and other organizations.

The Association's address is: 1601-13 Dime Building, Detroit, Michigan.



UPPER HALF OF IGNITER HEAD—center section and outer wall down to weld—is made in five operations by Marform process. Nine steps are usually required.

Gallium Now Available, But Uses Must Be Found

GALLIUM, at $140 an ounce, is the latest metal to hit the commercial market. The Aluminum Company of America is currently producing about 3,500 oz a month, but the problem now facing them is to find a market outside a few specialized fields.

The metal, which melts at body temperature, has long been used by the Atomic Energy Commission as a heat transfer agent in atomic piles. But the need for gallium is small because it can be recovered and reused. The only other application, except for small amounts used in research, is in the production of high-temperature thermometers.

Here are some of the rare metal's specifications: Melting point, 85.6 F; boiling point, 3,600 F; specific gravity, solid—5.904, liquid—6.095; linear coefficient of thermal expansion (solid) 1.8×10^{-6}. Unlike mercury, liquid gallium "wets" the surface of many materials. It forms strong amalgums, is currently being tested for dental work. One dental alloy can withstand a pressure of 66,000 psi. Its crystalline structure is orthorhombic.

U. S. Technical Societies Back Pan-American Group

PROPOSALS made at the first Pan-American Engineering Congress held in Rio de Janeiro last July for an Inter-American engineering organization have been unanimously approved by the Committee on International Relations of the Engineers Joint Council. The Committee favors the fullest cooperation with other engineering societies of the Americas to bring into being the proposed organization of engineering societies in the Western Hemisphere.

This action assures the full participation of United States engineering societies, with those of other American nations, at an organizational meeting to be held in Havana at a date to be announced later.

The objectives of the new organization would include the further advancement of engineering science and

practice, and development of engineering skills by direct exchanges among the participating societies; also to foster such collaboration among the members of participating societies and other international organizations as may be considered desirable.

The Engineers Joint Council is composed of representatives of the following societies: ASME, AICE, AIME, AIEE and ASCE.

New Form of Vanadium May Improve Alloy Steels

A NEW KIND OF VANADIUM for use in alloy steels has been discovered. It is a variety or isotope of the element, weighing one unit less than ordinary vanadium, but occuring only one part in 400 in the material as found in nature.

Discovered at both the University of Chicago's Argonne National Laboratory and the University of Minnesota independently, the new vanadium is unusual because it is only the seventh ever discovered out of the more than a thousand isotopes that have an odd number of neutrons and an odd number of protons.

Ordinary vanadium has atomic weight 51, while the new isotope that is presumably stable is 50. Other isotopes of vanadium are all artificially produced and destroy themselves in a relatively short time through their radioactivity. These have weights 47, 48, 49 and 52, respectively.

David C. Hess, Jr., and Mark G. Inghram of the Argonne National Laboratory became aware of the new kind of vanadium because neutron bombardment of the metal produced a kind of radioactivity that the normal metal does not give. Wallace T. Leland of the University of Minnesota made this discovery while investigating the heavier elements with a mass spectrometer.

Redesigned Controls, Heating and Lighting Featured in Latest New York Subway Cars

GREATER COMFORT for both passenger and operator is the result of many design innovations built into new subway trains that race up and down New York's Manhattan Island at rush-hour intervals of 90 sec. Smooth acceleration and deceleration, temperature-controlled circulating air, reduced car sway and fluorescent lighting please the passenger. Simple operation of power and brake controls make life easy for the motorman, while inside (instead of between-car) door controls mean additional safety and comfort for the conductor. One experimental train has illuminated route maps and air circulating systems that include Precipitrons and germicidal lamps.

Four 100-hp series motors, two on each truck, drive the cars from a 600-v d-c third-rail system. Each motor powers one axle through a flexible coupling and a spur gear drive. Speed of these motors is regulated by automatic relay circuits that cut banks of resistors in and out, change connections in the two pairs of motors from series to parallel operation and shunt portions of the field windings. Acceleration at a rate of 2.5 mphs to 45 miles per hour in 18 steps is thus obtained, compensation being made even for any condition of passenger loading. Smooth starts are automatic even though the motorman may immediately rotate his power control to the high-speed position.

Mechanical and electric braking are combined to bring trains to a stop at a deceleration rate of from 1.5 to 3 mphs. After the main power is shut off, the driving motors act as dynamic brakes until speed is reduced to about 10 mph. A compressed air system then takes over automatically and actuates clasp brakes.

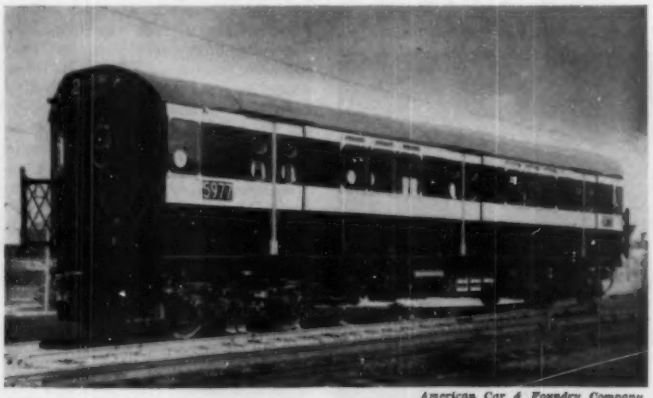
Vertical and horizontal oscillation of each car, either on the straight-a-way or on curves, is reduced by eight double-acting shock absorbers, four in each truck assembly. Four of the shocks control vertical movements, the other four, horizontal motions.

Instead of being perched on steps between cars, the conductor on the new trains stands in the unoccupied motorman's cab. While leaning out the window, he can observe entry and exit of passengers and still operate the doors in one side of one or more cars.

Every car has eight electric motors instead of air cylinders for operating six pairs of side doors. Each of four motors handles two adjacent door panels; the remaining four actuate single panels at the ends of the car. A pivoted lever arm with a roller or pin connector at the door end and a double reduction gear at the motor end links the motor shaft to the door panel. A horizontal bar retracted by a solenoid plunger and returned by a spring keeps each door positively locked closed.

The reversible door motors are adjusted to open the panels in 1½ sec and close them in 2 sec. Slamming is prevented by slowing the rate of travel just before the doors are closed or fully opened.

All of the door, drive motor, braking, fan and lighting control circuits are operated from a 32-v storage battery supply. Circuits in the individual cars are connected with those in other cars through the main couplers. Thirty-nine contacts for these circuits are automatically interconnected when coupling is made between cars.



American Car & Foundry Company

HORIZONTAL AND VERTICAL SHOCK ABSORBERS in wheel trucks reduce sway of subway cars. Four 100-hp d-c motors accelerate train at rate of 2.5 mphs in 18 steps to 45 mph. Master door controls are in cabs instead of between cars.

Washington Notes

Science Foundation Bill Amended and Passed by House

The movement dating back to 1944 to give an integral and independent position in government was assured last month by House passage of an administration bill establishing the National Science Foundation. The Senate having passed a similar bill a year ago, the two bills now go to conference for settlement of differences and then to President Truman for his signature.

The House made two important changes in the Senate-passed bill: (1) Appropriations for the Foundation were limited to $500,000 for the first year (as allowed in the budget) and outlays thereafter to $15-million annually; and (2) a tight loyalty check was included in an amendment offered by Rep. Howard W. Smith (D., Va.) requiring individual FBI clearance of every employee of the Foundation and the same careful screen for scholarships awarded by the agency.

While the bill is planned to foster basic research, it would, however, enable the Foundation to support studies in the field of applied science in National Defense in collaboration with the Secretary of Defense.

As embodied in the house bill, the foundation would have the following objectives:

1. To develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences.

2. To initiate and support basic scientific research in mathematics, physics, medicine, biology, engineering and other sciences through grants.

3. After consultation with the Secretary of Defense, to initiate and support scientific research in connection with matters relating to national defense by making contracts or other arrangements with research groups including grants, loans and other forms of assistance.

4. To foster interchange of scientific information among scientists in the United States and foreign countries.

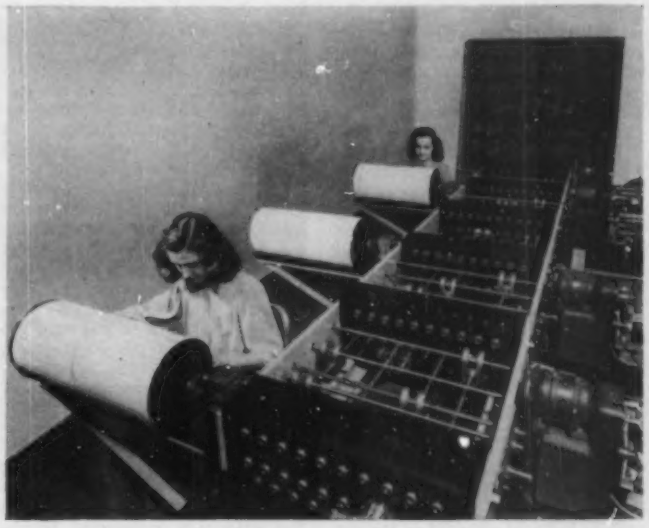
5. To evaluate scientific research programs undertaken by individuals and by public and private research groups, including scientific research programs of agencies of the Federal Government and to correlate the Foundation's scientific research activities with such programs.

6. To maintain a register of scientific and technical personnel and in other ways provide a central clearing-house for information covering all scientific and technical personnel in the United States, including its territories and possessions.

The executive committee of the 24-member National Science Board created under the bill would consult with the Secretary of Defense to assure adequate safeguards over information having military significance.

Members of the Board would be appointed by the President from among outstanding scientists and their names submitted to the Senate for confirmation. Consideration would be given to nominations submitted by the National Academy of Sciences, National Association of State Universities and Association of American Colleges and also Association of Land Grant Colleges and Universities.

The National Science Foundation would be headed by a director with a salary of $15,000 a year. Board members would get $25 a day when en-



"Bargain-Price" Analyzer Designed by NACA Engineer

A YOUNG ENGINEER at the National Advisory Committee for Aeronautics in Cleveland, Ohio has designed and built a full-grown mechanical differential analyzer at the bargain price of only $5,000. Using war surplus parts, H. W. Mergler of NACA's Instrument Research Section has assembled a machine for solving any problem that can be represented by differential equations. Accuracy is believed to be within one part in a thousand.

The analyzer consists of five mechanical integrators of a type developed by Lord Kelvin in 1876, torque amplifiers connected to each integrator for developing sufficient power to drive the mechanism, three revolving drums on which the data to be integrated is fed into and out of the machine, and gears and rods that are interconnected to conform to the elements of equation or data that is to be analyzed.

To solve a problem, the equation is written down and a schematic diagram evolved from it to show the proper interconnections to be made in the gears and rods. The data to be integrated are plotted in the form of a curve on an acetate plastic surface (paper cannot be used because atmospheric conditions cause it to contract or expand, causing error) and fed onto one or more of the revolving drums. As the drum rotates, the machine operator turns a handwheel controlling a pen, and traces the curve of the data. The gears and interconnecting rods then go into action, adding, subtracting, integrating and thus multiplying, dividing and differentiating to arrive at the solution, which appears on the third drum.

gaged in Foundation business, also travelling expenses. The executive committee of the board would consist of nine members and the director.

There is a move on foot to persuade Dr. Vannevar Bush to take leave from Carnegie Institute to become director.

Differences between the Senate and House versions of the Foundation bill are expected to be ironed out in joint committee early this month. Opposition to the House FBI clearance requirements is evident. Many civilian scientists are already on record as being opposed. The Justice Department and Mr. Lilienthal have also expressed disfavor. The final version presented to the President may be tempered in this one respect.

Ordnance Test Facilities Greatly Expanded at NOL

Probably the largest assemblage of equipment designed to test ordnance equipment under simulated field conditions has been collected in the new Ordnance Environmental Laboratory building recently completed at the Naval Ordnance Laboratory, White Oak, Maryland.

NOL Scientists are equipped to duplicate practically any temperature condition. They can expose mines, depth charges and torpedoes to the arctic cold and, within a matter of minutes, expose the same weapons to tropical heat. They can test these items in seawater heated or cooled to any temperature and simulate the great pressures found half a mile beneath the surface of the ocean.

The Navy feels that the laboratory will pay for itself out of savings resulting from its work within the next five years. Key personnel analyze the economics involved from this practical viewpoint:

"Weapons and all their components have to be designed and developed to withstand shock, vibration, temperature, pressure and humidity. In this laboratory, all these forces and physical factors of environment can be readily applied to every new device. Within a few hours its ability to withstand and perform under any condition can be determined. Moreover, its performance can be observed and measured with all the precision of laboratory experiment. Any failures can be diagnosed and redesigned devices can be rapidly retested. When Ordnance is ready for full scale production, the device can be given a thorough evaluation test before major costs are incurred. Simulation of field conditions in the laboratory thus helps economy in national defense."

Equipment in the new building can simulate these field conditions: (1) Slowly applied stresses of ocean pressures and rocket propulsion; (2) impulsively applied stresses of water entry, gun launching and impact on armor; (3) cyclically applied stresses of transportation and rough handling; (4) atmospheric conditions of temperature, humidity and altitude; (5) corrosive atmospheres of land and sea; and (6) sea water temperatures, currents and chemicals.

Official U. S. Navy Photograph

105-TON HYDROSTATIC PRESSURE CHAMBER is nearly large enough to house a one-man submarine. Pressure simulating ocean depths of half a mile can be produced.

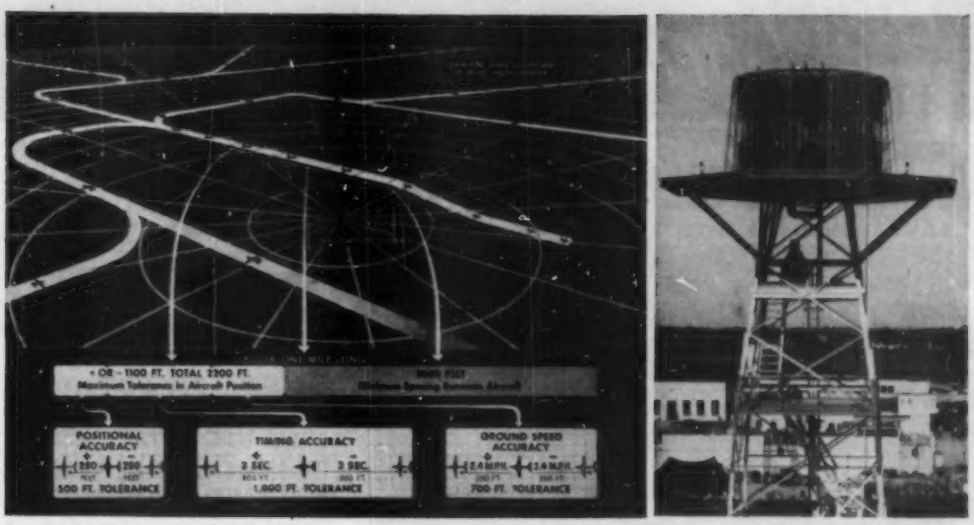
Atomic Ships and Airplanes Included in Reactor Program

The Atomic Energy Commission is now definitely launched on a program that holds much promise for the application of atomic energy to peacetime uses such as aircraft, ships and power.

The kernel of the program is an experimental breeder reactor the construction of which work is to start immediately at Arco, Idaho. The breeder reactor is designed to try out the possibility of transmitting non-fissionable uranium 238 into fissionable plutonium so that it results in more fissionable material being produced than is consumed. It is hoped that in the breeder reactor the fission of U-235 can create neutrons that will react on the plentiful and, at present, unuseable U-238 to convert at least a portion of it to a different element, plutonium. The surplus fissionable material could then be extracted from the reactor and used for power.

Design work is underway and construction is expected to start this spring on a materials testing reactor, also to be located at the Idaho reactor testing station. The purpose of this reactor, according to AEC, will be to test various reactor construction materials under intense neutron bombardment far greater than what has been used in the present reactors at the Hanford Plutonium Works. The materials to be tested will be contained in test pockets. Since the power reactors of the future will be operated at greater neutron intensities than those in operation today, the Commission pointed out that it is important to learn in advance how various materials that might be used in the structures, cooling systems or shields will react under these conditions. The materials testing reactor has particular significance in the development of reactors for the propulsion of aircraft, because it points in the direction of compact, high-radiation-density reactors necessary if aircraft are atom-driven.

A reactor for ship propulsion (naval or submarine) will be located later on at the Idaho Station. Actual construction of this reactor is not scheduled to start until 1952. The engineering and development work is now being carried out at Argonne National Laboratory and by Westinghouse.



NAVIGATIONAL ACCURACY is key to flow of airplane traffic. Landing rate is 120 planes per hr approaching at 30-sec intervals at 120-mph ground speed. Antenna (right) for omni system has "lighthouse lens" for cutting out interference from ground waves.

Dual-Pattern Omni-Range System Solves Air Traffic Jams

A NEW OMNI-RANGE NAVIGATIONAL SYSTEM shows promise of untangling bad-weather traffic jams and boosting landing rates in airport terminal zones. Under development by the Sperry Gyroscope Company for the Air Force's All-Weather Flying Division, the device largely overcomes the azimuth or angle accuracy deficiency of polar coordinate systems. Accuracy is better than $\pm\frac{1}{2}$ deg within a 30-mile radius.

In the basic omni-range technique, an antenna having a limacon (heart shaped) pattern is rotated so that its field strength at any point in space varies as a sine wave. The wave modulation thus produced is of the same frequency as the antenna speed of rotation and the phase of the wave is directly proportional to azimuth angle around the omni station.

If the phase of this signal is compared with a reference signal of constant phase, azimuth can be determined. If the reference signal is synchronized with true north, the phase difference between the two signals equals azimuth. Thus, one degree of phase becomes one degree in azimuth.

In this simple technique, azimuth accuracy is limited to the accuracy of existing techniques for measuring electrical phase. If some method of producing greater phase shift per degree of accuracy can be used, azimuth accuracy can be improved fundamentally.

This is relatively simple to achieve at microwave frequencies. An antenna pattern of 11 lobes or scallops can be used. Here, 11 lobes will produce 11 cycles of sine wave at any point in space for one complete rotation, and the phase shift per degree of azimuth becomes 11 times greater. One degree in phase equals 1/11 deg of azimuth. This measurement, however, has 11 points of ambiguity since individual cycles, which correspond to the lobes, are not separately recognizable.

Ambiguity can be removed, the improved accuracy still being retained, by superimposing the 11-lobe pattern on the original single limacon pattern. This creates a limacon with scalloped edges, each scallop being equivalent to one of the lobes.

The 11 lobes still produce 11 cycles of sine wave in each revolution of the antenna, but the average value of the 11 cycles now varies according to the sine wave produced by the basic limacon pattern.

The variation, produced by the basic limacon, makes it possible to identify each of the 11 cycles. The two sine waves produced act as "coarse" and "fine" signals for exact, unambiguous measurement of azimuth angle.

In the present equipment design, the antenna rotates at 1,650 rpm. This produces a "course" sine wave frequency of 27.5 cycles for the limacon and a "fine" frequency of 302.5 cycles for the 11 lobes.

Constant phase reference signals of the same frequency are broadcast in all directions so that the phase of the rotational signals can be compared with a northerly reference to obtain true azimuth.

The entire system operates on a narrow band carrier frequency in the 5,000-megacycle region. The system also is designed so that it can be integrated with other units to form a complete air navigation and traffic control system operating entirely within a narrow frequency band.

The rotating antenna consists of a vertical stack of two small tripoles, mounted between a pair of 10-in. disks. The tripoles produce the limacon pattern and the two disks act as a wave guide. Vertical dielectric staves (or microwave phase shifters) mounted between the disks produce the 11 lobes on the basic limacon.

The constant phase reference signals are produced by two generators geared directly to the rotating antennas. Phase is fixed by the meshing of the gears. Reference signals are broadcast on an f-m subcarrier impressed on the 5,000-mc carrier.

Dow Corning Silicone News

DC SILICONES

DOW CORNING CORPORATION, MIDLAND, MICHIGAN • APRIL, 1950

DOW CORNING SILICONE INSULATION SAVES OVER $8,000 A YEAR ON 4 MOTORS

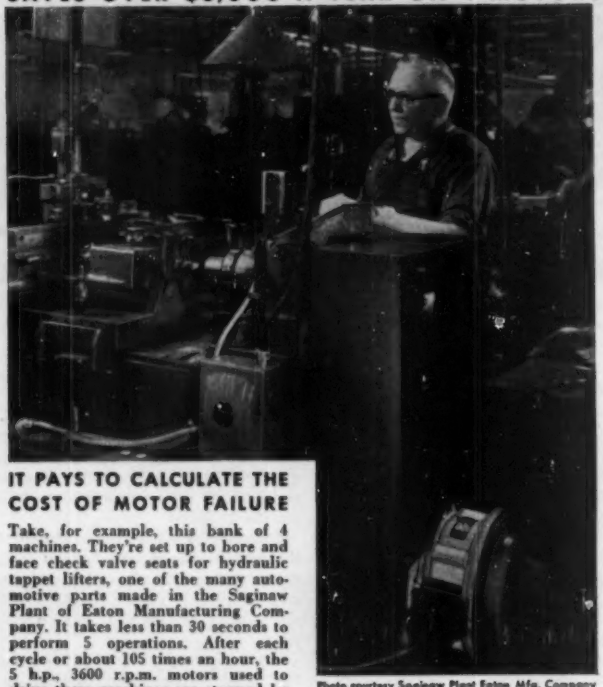


Photo courtesy Saginaw Plant Eaton Mfg. Company

IT PAYS TO CALCULATE THE COST OF MOTOR FAILURE

Take, for example, this bank of 4 machines. They're set up to bore and face check valve seats for hydraulic tappet lifters, one of the many automotive parts made in the Saginaw Plant of Eaton Manufacturing Company. It takes less than 30 seconds to perform 5 operations. After each cycle or about 105 times an hour, the 5 h.p., 3600 r.p.m. motors used to drive these machines are stopped by applying direct current to the windings. That steps up production, but it raises hob with ordinary motors.

In this service, Class A insulated motors lasted from 2 days to 2 weeks or an average of about 8 days. That amounts to something like 32 failures per year per motor. Each failure cost at least 3 hours of down time plus $80.00 for rewinding with Class A materials. At this rate, it would have cost the Saginaw Plant $10,000 a year to keep the four machines operating!

About a year ago, these motors were rewound with Dow Corning Silicone (Class H) Insulation at a cost of about $150.00 each. Minimum life for Class H motors in this service is 6 months. Maintenance costs that would have totalled $10,000 a year have been cut to $1,200. That's a net saving of more than $8,000 plus a good 400 man hours of labor and a bonus of some 40,000 parts that would have been lost because of down time.

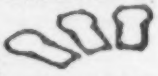
Industry needs the kind of help you can give by using Dow Corning Silicone (Class H) Insulation to cut maintenance costs, to increase productivity or to reduce the size and weight of motors, generators, transformers and solenoids by 50 to 100%. For more information on Silicone Insulation, call our nearest branch office or write for data sheet Q-16.

Courtesy United Air Lines

SILASTIC*

SAVES 93% OF THE FLIGHT DELAYS CAUSED BY PUSH-ROD PACKING LEAKAGE.

Pushrod housing seals fabricated of Silastic by the Arrowhead Rubber Company of Downey, California, remain soft and pliable after 1100 engine hours in contact with hot oil at operating temperatures in the range of 450°F. That kind of performance has almost eliminated flight delays due to pushrod packing leakage. Use of these Silastic seals also cuts maintenance costs and minimizes the hazard of oil leakage.



ARROWHEAD'S new rocker box cover gaskets of Silastic are also gaining general acceptance in the air transport industry. Tests in service indicate that these Silastic gaskets are easier to install and that they have superior resistance to compression, hot oil and high operating temperatures.

That kind of performance is characteristic of the many Silastic seals used in aircraft, automobile and diesel electric engines. New Silastic stocks introduced during the past year have multiplied the usefulness of silicone rubber as an extreme temperature material for gasketing and sealing and for insulating wire, cable and electrical equipment. Notable improvements in physical properties and fabrication technics have greatly increased the usefulness of mechanical goods molded of Silastic. For more information call our nearest branch office or write for data sheet Q-16A.

*T.M. Reg. U.S. Pat. Off.

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Deflections of Perpendicularly Loaded Split Circular Rings

M. M. LFMCOE
Washington University

FORMULAS FOR THE DEFLECTION of a split uniform circular ring perpendicular to the plane of the ring are given for various positions of the load. Methods of developing those formulas are demonstrated.

In Fig. 1 is shown a split uniform circular ring of radius R, loaded with a force P applied perpendicular to the plane of the ring at the point B. At the point Q, the bending moment M and the twisting moment T due to the load P are respectively:

$$M = P R \sin (\beta - \theta) \quad (1)$$
$$T = P R [1 - \cos (\beta - \theta)] \quad (2)$$

Also, if there were a unit load at the point A, there would be at point Q a bending moment m and a twisting moment t due to that unit load. These are given by the following formula

$$m = R \sin (\alpha - \theta) \quad (3)$$
$$t = R [1 - \cos (\alpha - \theta)] \quad (4)$$

From strain energy considerations, the deflection Δ of the point A can be formulated. If E is the modulus of elasticity and G is the shear modulus and if I is the moment of inertia about the neutral axis of a cross-section, and J is the polar moment of inertia of a cross-section, the formula is

$$\Delta = \int_0^{\phi} \frac{M m R \, d\theta}{E I} + \int_0^{\phi} \frac{T t R \, d\theta}{G J} \quad (5)$$

The angle ϕ equals the smaller of angles α or β. Substituting Eqs (1), (2), (3) and (4) into Eq (5) gives:

$$\Delta = P R^3 \int_0^{\phi} \left\{ \frac{\sin (\alpha - \theta) \sin (\beta - \theta)}{E I} + \frac{[1 - \cos (\alpha - \theta)] [1 - \cos (\beta - \theta)]}{G J} d\theta \right\}$$

From the trigonometric identities

$$\sin (\alpha - \theta) \sin (\beta - \theta) = \tfrac{1}{2} [\cos (\alpha - \beta) - \cos (\alpha + \beta - 2\theta)]$$
$$\cos (\alpha - \theta) \cos (\beta - \theta) = \tfrac{1}{2} [\cos (\alpha - \beta) + \cos (\alpha + \beta - 2\theta)]$$

The formula for Δ becomes:

$$\Delta = \frac{P R^3}{2 E I} \left[\int_0^{\phi} \cos (\alpha - \beta) d\theta - \int_0^{\phi} \cos (\alpha + \beta - 2\theta) \, d\theta \right] + \frac{P R^3}{2 G J} \left[\int_0^{\phi} \cos (\alpha - \beta) \, d\theta - \int_0^{\phi} \cos (\alpha + \beta - 2\theta) \, d\theta + \int_0^{\phi} [1 - \cos (\alpha - \theta)] \, d\theta - \int_0^{\phi} \cos (\beta - \theta) \, d\theta \right] \quad (6)$$

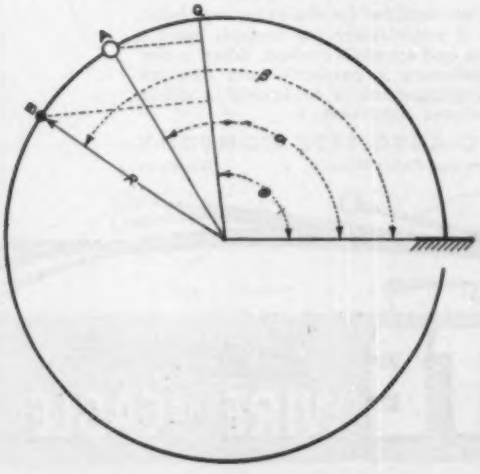
Integrating Eq (6) gives

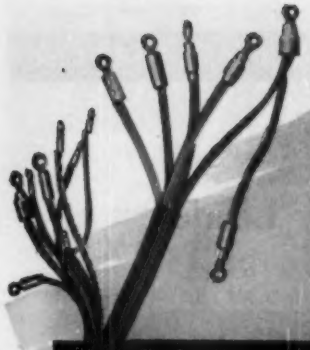
$$\Delta = \frac{P R^3}{E I} \left[\frac{\phi \cos (\alpha - \beta)}{2} + \frac{\sin (\alpha + \beta - 2\phi) - \sin (\alpha - \beta)}{4} \right] + \frac{P R^3}{G J} \left[\frac{\phi \cos (\alpha - \beta)}{2} - \frac{\sin (\alpha + \beta - 2\phi) - \sin (\alpha + \beta)}{4} + \phi + \sin (\alpha - \phi) - \sin \alpha + \sin (\beta - \theta) - \sin \beta \right] \quad (7)$$

From Eq (7) formulas can be developed for Δ for various positions of points A and B.

Formulas for various positions of points A and B are given below. (*continued on page 157*)

Fig. 1—Split circular ring loaded by a force perpendicular to the ring at point B. The deflection Δ at point A is to be calculated.





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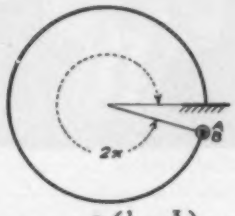
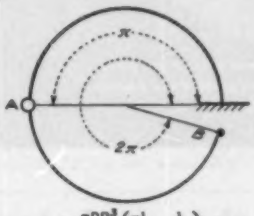
Deflections of Perpendicularly Loaded Split Circular Rings (continued)

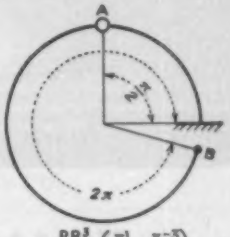
Δ = deflection at point A
P = load at point B
R = radius of ring
E = modulus of elasticity
G = shear modulus
J = cross-section polar moment of inertia
I = cross-section moment of inertia about neutral axis



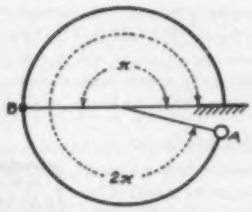
$$\Delta = \pi PR^3 \left(\frac{1}{EI} + \frac{3}{GJ}\right)$$



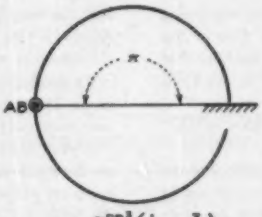
$$\Delta = \frac{\pi PR^3}{2}\left(\frac{-1}{EI} + \frac{1}{GJ}\right)$$



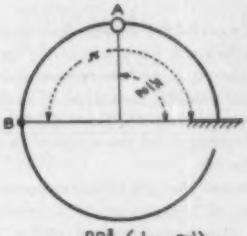
$$\Delta = \frac{PR^3}{2}\left(\frac{-1}{EI} + \frac{\pi-3}{GJ}\right)$$



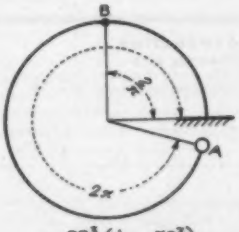
$$\Delta = \frac{\pi PR^3}{2}\left(\frac{-1}{EI} + \frac{1}{GJ}\right)$$



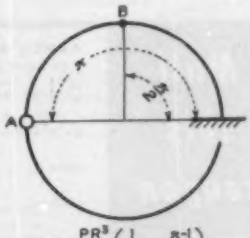
$$\Delta = \frac{\pi PR^3}{2}\left(\frac{1}{EI} + \frac{3}{GJ}\right)$$



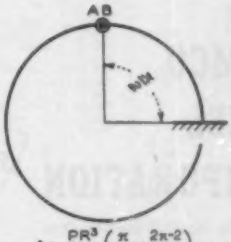
$$\Delta = \frac{PR^3}{2}\left(\frac{1}{EI} + \frac{\pi-1}{GJ}\right)$$



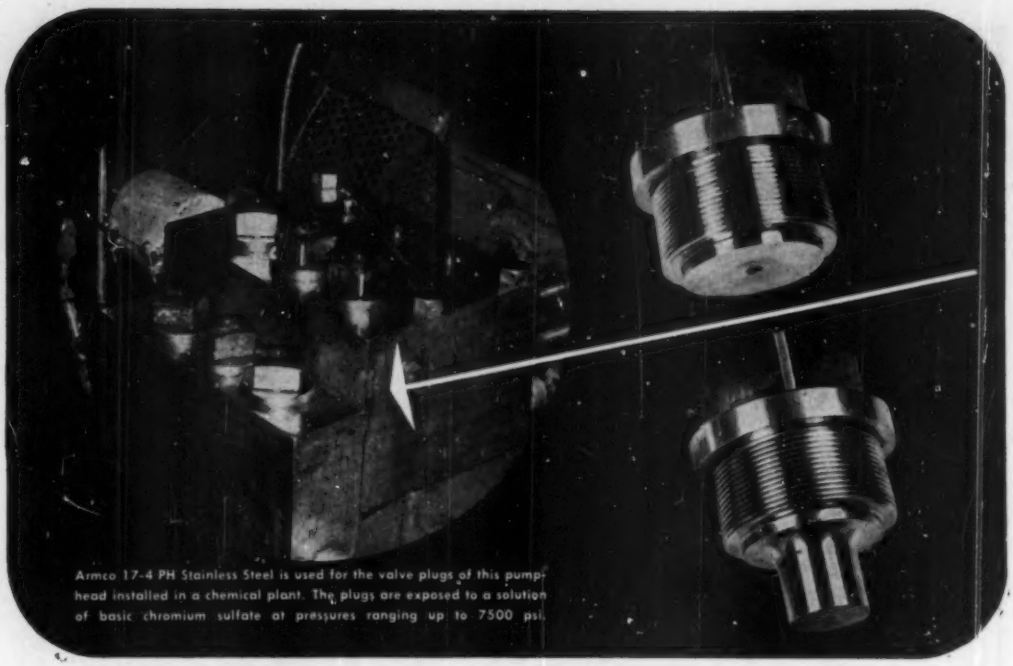
$$\Delta = \frac{PR^3}{2}\left(\frac{-1}{EI} + \frac{\pi-3}{GJ}\right)$$



$$\Delta = \frac{PR^3}{2}\left(\frac{1}{EI} + \frac{\pi-1}{GJ}\right)$$



$$\Delta = \frac{PR^3}{2}\left(\frac{\pi}{EI} + \frac{2\pi-2}{GJ}\right)$$



Armco 17-4 PH Stainless Steel is used for the valve plugs of this pump-head installed in a chemical plant. The plugs are exposed to a solution of basic chromium sulfate at pressures ranging up to 7500 psi.

Heat-treat this stainless for hardness after finish-machining

New Armco 17-4 PH Stainless Steel (a precipitation hardening grade) offers you many cost-saving advantages. One of the most important is the ***low-temperature*** heat treatment that gives your products hardnesses of Rockwell C40 to 45. Yield strengths range from 170,000 to 200,000 psi.

Heat treating in the low-temperature range of 850° to 900° F. does the job.

This means you can finish-machine precision parts ***before*** hardening. In fact, you get rid of finishing problems all along the line. There is no danger of cracking or distortion. No scaling either, and no stress-relief treatment is needed. Only an easily-removed heat tint results from the hardening operation.

Both the machining characteristics and corrosion resistance of Armco 17-4 PH Stainless Steel closely approach the 18-8 grade.

Production men report excellent results with Armco 17-4 PH in the production of gears, cams, shears, pinions, chains, valve plugs, shafting, special nuts, bolts, fasteners, and precision instrument parts.

If your products need high strength and hardness, or they can be made more salesworthy with the good corrosion resistance offered by Armco 17-4 PH, write for more information about this newest Armco special-purpose steel. Just fill in the handy coupon and drop it in the mail.

see our CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

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Dimensional Tolerances of Plastics

GEORGE S. LAAFF
Director of Research and Development, The Bolta Company

THERMOSETTING RESINS generally have greater resistance to dimensional change than thermoplastic resins. However, the properties of a part made from an individual resin are also affected by temperature and pressure of molding and the incorporation of other materials such as fillers, dyes, lubricants, stabilizers or other resins.

When a plastic product cools from formation temperature to room temperature a loss in dimension occurs. In most calendering, extruding and laminating operations, accuracy in the final product involves compensating calculations of the products' shrinkage only; in molding operations comparison of metal and plastic shrinkage must be made. Uneven cooling, curing and the union of materials with dissimilar coefficients of linear expansion cause stresses in a product, which are manifested by distortion. These strains are especially troublesome in complex molding operations. Such dimensional changes can of course be minimized by careful design of molds and molding machines, but the following are more or less "standard" tolerances.

CALENDERED AND EXTRUDED PRODUCTS. Calendering operations should produce thicknesses with a plus tolerance of about 8 percent and a minus tolerance of about 2 percent. Width should not vary more than 1 percent from specifications.

The problems of maintaining dimensional accuracy in extruded products parallel to some extent those of calendered materials:

Cross-Sectional Dimension, in.	Tolerance, in.
1	±1/64
1 to 3	±1/32
3 and over	±1/32 to ±3/64

Generally, tolerances will run from 5 to 8 percent in extruded products.

CAST PRODUCTS. Casting operations require tolerances from 2 to 4 percent for simple products. Greater tolerances must be expected in complicated castings, and in decorative work where dimensional accuracy is usually sacrificed for appearance. Allowable tolerances on machined castings would be independent of casting considerations, since they are governed by the capabilities of the machining equipment.

DIMENSIONAL TOLERANCES IN LAMINATED PRODUCTS

Paper-based laminate sheets should be within 2 to 4 percent of the specified dimension. Cloth-based laminates require tolerances 2 to 3 times higher than paper-based products. Tolerances on tubes and rods should be slightly greater than for sheets in thin sections, but slightly lower than sheet tolerances in thick sections. The following tolerances can be expected with paper-based laminate sheets, tubes and rods.

SHEET

Thickness, in.	Tolerance, in.	Thickness, in.	Tolerance, in.
1/32	±0.0035	7/32	±0.011
3/64	±0.0045	1/4	±0.012
1/16	±0.005	3/8	±0.017
3/32	±0.007	1/2	±0.021
1/8	±0.008	5/8	±0.024
5/32	±0.009	3/4	±0.027
3/16	±0.010	7/8	±0.030
		1	±0.033

TUBES AND RODS

Diameter, In.	Tolerance, in.
Less than 1/16	±0.006
1/16 to 1/8 (not incl.)	±0.007
1/8 to 1/4 (not incl.)	±0.009
1/4 to 1/2	±0.011

DIMENSIONAL TOLERANCES IN MOLDED PRODUCTS

The method by which a product is molded has some bearing on tolerances. Compression molding methods do not usually give the close tolerances attained in transfer and injection molding. Tolerances on compression molded products in the direction of die travel will be from 0.006 to 0.010 in. per in.; these tolerances are from 25 to 50 percent higher than values in the perpendicular direction. Multiple cavities will also increase the tolerances approximately 25 percent. The tolerances shown at the right can be expected in simple molded products.

While thermoplastics are not essentially close tolerance materials, it is possible to fabricate them to fairly precise dimensions, from sheets, rods, tubes or other semi-finished shapes; however, such machining operations are sometimes quite costly, depending on the intricacy of shape and stringency of tolerances required.

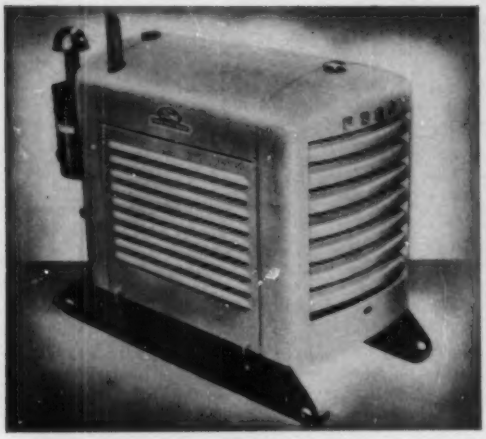
Plastic	Filler	Tolerance, in. per in.		
		Compression Molding*	Injection Molding	Transfer Molding
Phenolic		0.010		0.006
Phenolic	Cotton Rag	0.008		0.005
Phenolic	Woodflour	0.006	0.004	0.004
Phenolic	Cotton Flock	0.008		0.005
Phenolic	Paper	0.010		0.005
Phenolic	Asbestos	0.006	0.004	0.004
Phenolic	Mica	0.006	0.004	0.004
Urea Formaldehyde	Cellulose	0.008		0.006
Melamine	Cellulose	0.006		0.004
Melamine	Asbestos	0.006		0.004
Melamine	Rag	0.008		0.006
Ethyl Cellulose			0.005	
Cellulose Acetate			0.005	
Cellulose Acetate Butyrate			0.005	
Polystyrene			0.004	
Methyl Methacrylate			0.004	
Polyvinyl Chloride Acetate			0.004	
Polyethylene			0.004	

* In the direction of die travel.

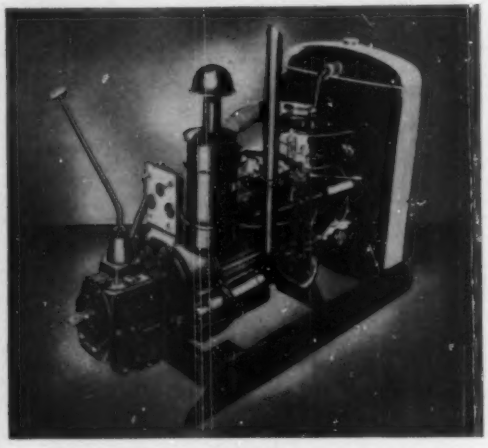
All material based on an article from "Plastics Encyclopedia," edited by William Schack, to be published shortly by Chemical Publishing Company

DESIGN DETAILS AND DATA ON

NEW COMPONENTS–



ENCLOSED TYPE POWER UNIT shown above has 337 cu. in. displacement, a 6.5 to 1 compression ratio, and develops 258 ft-lbs torque. It has eight cylinders and skid-type mountings.



OPEN TYPE UNITS are also available in all models. Engine above has 226 cu. in. displacement, a 6.7 to 1 compression ratio, and develops 183 ft-lbs torque. It has six cylinders.

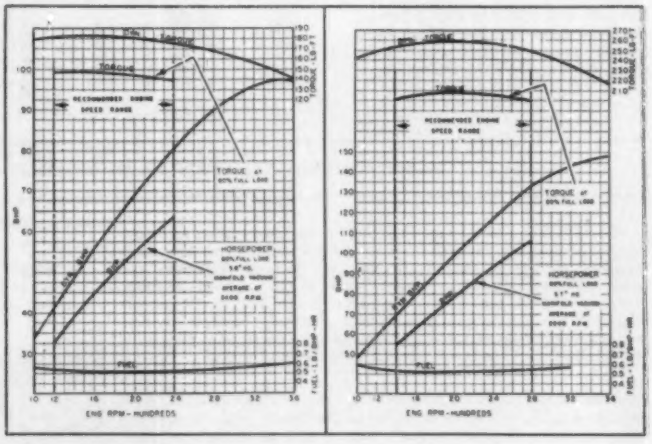
Power Units Come in Five Complete Assemblies

Motors have four, six, or eight cylinders and are equipped with skid-type mountings.

These motors are offered complete with radiator, instrument panel and SAE or Ford type housing, and may be ordered with or without clutch or power takeoff. They have either three, four, or five-speed transmissions. Any model may be either open or enclosed.

The complete line includes two six-cylinder models, two v-type, eight-cylinder models, and one of four cylinders. Piston displacement of the four-cylinder unit is 120 cu in.; with 226 and 254 cu in. in the six-cylinder models, and 239 and 337 cu in. in the eight-cylinder models. All models have series flow cooling, assuring more uniform water temperatures. Torque outputs vary from 84 to 258 ft-lbs, and horsepowers are comparable.

Ford Motor Co.,
Industrial Engine Sales Dept.,
Dearborn, Mich.



PERFORMANCE CURVES are given for the "226" and "337" engines only. The dynamometer hp and torque curves are ratings for complete engine assemblies, including water pump and generator, but less fan. These figures are for normal operation at air temperature of 60 deg. F, and at sea level. The 80 percent hp and torque curves show the ratings for continuous speed and load operation under normal conditions. The "226" is a six cylinder engine, and the "337" has eight cylinders.

Small Transmission Uses A Unique Series of Linkages To Obtain Infinite Speed Variation

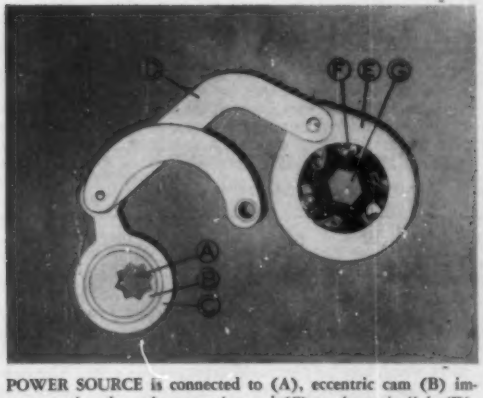
Transmission is beltless, gearless, and non-hydraulic. A series of linkages give infinitely variable speed from zero to maximum.

Called the "Model 14 Zero-Max", this small transmission is rated at 10 in. lbs torque. Speed changes can be made whether the unit is running or not. This speed change is instantaneous. The standard speed ratio is 4 to 1, and speed changes are infinitely variable up to this limit. When the control lever is in the full "slow" position, the output shaft does not turn at all—giving zero output speed, no matter what the input speed.

The "Zero-Max" is small—Model 14 is only 4 by 2¾ by 1¼ in. in body size. It can operate in any position and is readily incorporated in the design of any product. Transmissions are available with or without a case, or with a reversing mechanism. Special direction, special mounting arrangements, and other special constructions can be supplied on request. Suggested applications include use with fans, automatic washing machines, stoker blowers, mixers, blueprint machines, and small machine tools.

Revco, Inc., Dept. PE, 405 Thorpe Bldg., Minneapolis, Minn.

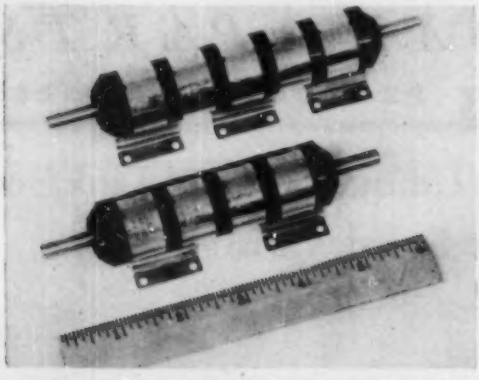
AT FULL "SLOW" SETTING, the output shaft does not turn, regardless of input speed. At full "fast" setting, the speed ratio is 4 to 1. Transmissions come with or without case. Special mountings and special assemblies can be developed on quantity orders to meet individual product requirements.



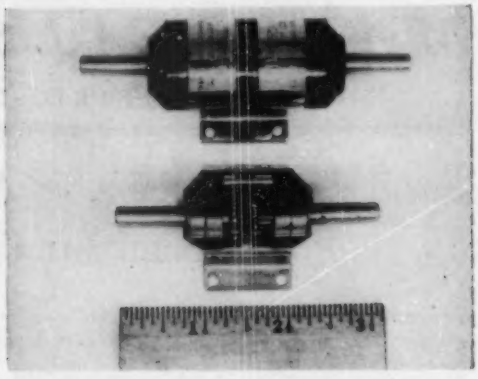
POWER SOURCE is connected to (A), eccentric cam (B) imparts motion through connecting rod (C) to the main link (D), which is thrown towards the over-riding clutch (E). Clutch imparts motion in clockwise direction only. On return half of cam motion another similar linkage takes over.

COMPLETE ASSEMBLY (above) shows four linkages which form complete assembly. The secondary link positions all cams and controls speed ratio. When set at full "slow" position, the connecting rod moves straight up and down, and imparts no motion to the main link, no matter what the input speed.

CONTINUED ON PAGE 162



TYPE 5A (SINGLE SECTION) has a maximum ratio of 15 to 1. Type 5B (double section) has a maximum ratio of 225 to 1. Gears are 48 pitch spur type, made from pinion rod and case hardened. Units with precision hobbed gears of 96 pitch are also available for extremely precise applications.

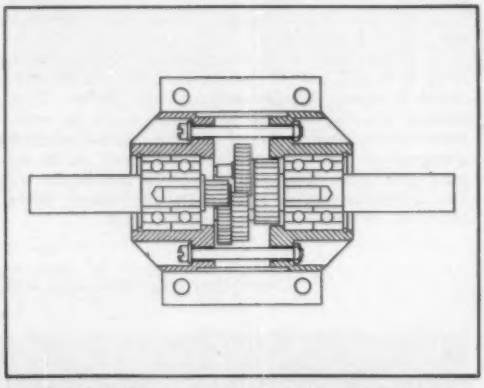


ADDING ONE OR TWO ADDITIONAL GEARING SECTIONS to the standard three speed unit gives gear reduction ratios as high as 750,000 to 1. These additions provide several hundred ratios between 1,000 to 1 and 750,000 to 1, in addition to the 500 or more ratios with 1, 2, and 3 section units.

Miniature Speed Changers Have Extreme Speed Ratios

Used for fixed ratio speed changing in instrument, control, regulator or test unit applications, these standard units give gear reduction as high as 750,000 to 1. High ratios are obtained by adding one or two additional gearing sections to the standard three-section units. The addition of still another section with a maximum ratio of over 11 million to 1 is structurally possible, but applications would be limited. Input speeds as high as 50,000 rpm, and output torques up to 2 lb-in. are permissible. Very high ratios in hobbed gears and "zero backlash" construction can be furnished at reduced torque rating. Weights of 4 and 5 section units are approximately 6 and 7 oz, respectively. Body diameter is 1.050 in.; body lengths are 3-$\frac{1}{16}$ in. for 4 section unit and 4-$\frac{3}{4}$ in. for 5 section units.

Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.



DRAWING SHOWS standard gear train. Newest feature is a torsional spring which takes out backlash and special hobbed and case hardened gears. Special gears are 96 pitch, with a 20 deg pressure angle. Standard gears are 48 pitch, and are made from pinion rod. Drive shaft is stainless steel, mounted in permanently lubricated, shielded ball bearings.

New Line of Timing Switches Have Interchangeable Parts

Series TS50 automatic time switches includes models with single pole, single throw; single pole, double throw; double pole, single throw; and a special low voltage switch. They can be used for controlling electric signs, advertising display, fans, refrigerator defrosters, pumps, blowers, and other related applications.

The operating mechanism of all models is identical. Because of Inter-Matic's unique design, switch assemblies can be purchased separately and any model can be converted to any other model by simply changing switch assemblies. Any model of the TS50 Series can be converted to a portable plug-in unit by merely attaching a few small parts which may be purchased separately as a kit. The new Inter-Matic provides up to 12 "on" and "off" operations every 24 hours. No Special dial is required when adding trippers, nor is it necessary to remove the dial.

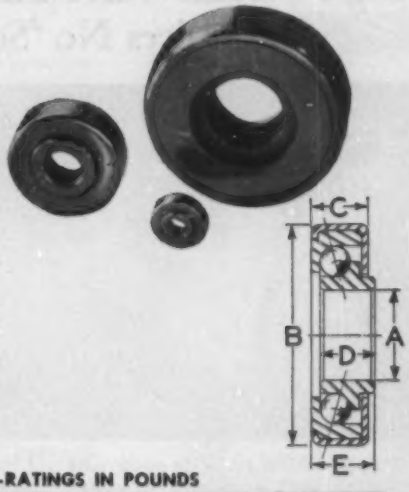
International Register Co., 2624 W. Washington Blvd., Chicago 12, Ill.

CONTINUED ON PAGE 164

"Commercial" Ball-Bearing Data...#7 of a Series

WE WILL BE GLAD TO SEND YOU COPIES OF THE PREVIOUS ADVERTISEMENTS IN THIS SERIES.

TYPE A UNGROUND
RADIAL-THRUST BALL BEARINGS



APPLICATIONS: For anti-friction performance equal to expensive precision bearings where load and speed requirements are within limits of "Commercial" ball-bearing ratings (see table below).

Replace plain sleeve bearings or bushings—often at no greater cost, since costly machining and assembly time is eliminated.

For combination radial and thrust loads or pure radial loads—almost limitless applications.

FEATURES:

Ball-bearing performance at low cost.
Race rings are carefully machined and smoothly finished—carburized, hardened and tempered.
Case—pressed on outer ring—is drawn from unhardened flat steel.
Balls are of highly polished, hardened steel.

DIMENSIONS IN INCHES—RATINGS IN POUNDS

Bearing No. New	Bore A +.004" −.000"	Outside Diam. B +.002" −.003"	Width C	Width D	Width E +.010" −.010"	Balls		Load Rating at 600 RPM
						No.	Size	
CS 1777X1	1/8	1 1/16	1/16	3/32	5/32	11	1/8	29
CS 1778X1	.192	1 1/16	1/16	3/32	5/32	11	1/8	29
CS 1779X1	3/16	1 1/16	1/16	3/32	5/32	11	1/8	29
CS 1780X1	1/4	1 3/16	3/64	3/64	3/64	10	9/64	60
CS 1781X1	1/4	3/4	1/16	1/64	1/64	12	1/8	31
CS 1782X1	5/16	1 3/64	1/32	1/32	3/32	11	5/64	65
CS 1783X1	5/16	1 13/64	1/32	3/64	1/32	11	1/8	115
CS 1784X1	3/8	1 15/32	1/32	1/32	3/32	13	1/4	135
CS 1785X2	.445	29/32	1/64	1/32	3/32	16	1/8	42
CS 1786X1	1/2	1 15/32	1/32	3/64	1/32	13	1/4	135
CS 1787X1	5/16	1 15/32	1/32	3/64	1/32	13	1/8	135
CS 1788X1	1/2	1 13/16	1/32	1/32	1/32	13	5/64	210
CS 1810X1	1/2	2 1/16	1/16	1/32	1/32	13	5/64	410
CS 1789X1	5/8	2 1/64	1/16	1/32	1/32	14	5/64	230
CS 1790X1	3/4	2 5/16	1/16	1/32	1/32	17	5/64	260
CS 1791X1	1	2 5/16	1/16	1/32	1/32	17	5/64	260
CS 1792X1	1	2 1/16	1/16	1/64	1/32	13	5/64	410
CS 1793X1	1 1/8	2 1/16	1/16	1/32	1/32	17	5/64	260
*CS 1794X1	1 1/8	3 3/64	1/16	1/32	1/32	14	1/8	580
*CS 1795X1	1 1/8	3 3/64	1/16	1/32	1/32	14	1/8	580
*CS 1796X1	1 1/8	3 3/64	1/16	1/32	1/32	14	1/8	580
*CS 1811X1	1 1/8	3 3/64	1/16	1/32	1/32	18	1/8	750
*CS 1797X1	1 1/8	3 1/16	1/16	1/32	1/32	18	1/8	750
*CS 1798X2	1 1/16	3 1/16	1/16	1/32	1/32	18	1/8	750
*CS 1799X1	2	4 1/2	1/16	1 1/64	1/32	18	5/32	940
*CS 1800X1	2 1/8	4 1/2	1/16	1 1/64	1/32	18	5/32	940

* Bearings so marked have bores ground to plus .001"-minus .000".

For load ratings at other speeds multiply the rating at 600 RPM by the following factors:

50 RPM	100 RPM	300 RPM	800 RPM	1000 RPM
2.50	1.80	1.30	.88	.78

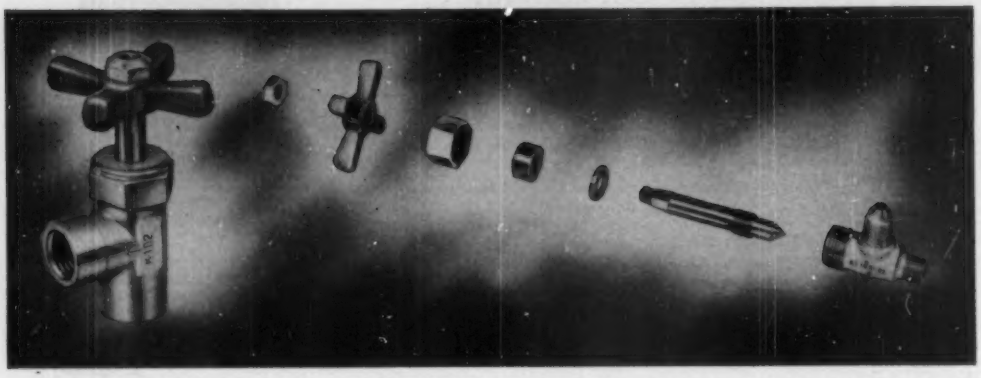
NEW SCHATZ CATALOG NO. 11

40 pages of dimension data and load rating tables make it easy to pick the right "Commercial" bearing for *your* application. Also included is information on Schatz Engineering Service, which has helped many manufacturers cut production costs by adapting or designing a special low-cost bearing to fit specific needs. Write for your free copy.

The Schatz Manufacturing Company
6758 FAIRVIEW AVENUE, POUGHKEEPSIE, N. Y.

SCHATZ
"Commercial"
BALL BEARINGS

Angle Needle Valve Has No Packing Washer, Requires No "Squeeze" To Prevent Leakage



THE MODEL K-102 angle needle valve will allow an operation to meter liquids and gases accurately and without leakage at pressures up to 1,500 psi. An "O" ring and backup washer prevent stem leakage when fluid power lines up to that pressure. Since there is no old style packing washer to be compressed, the valves are especially easy to open and close. The stainless steel needle is ground to form a perfect seat. The use of stainless steel gives long service life and resistance to corrosion. The valve body is forged to give both light weight and extra strength. These valves come in two standard sizes: the K-102-4, with ¼ in. internal pipe threads, a 5/32 in. handle movement, and a total weight of 2 oz; and the K-102-6, with ⅜ in. internal pipe threads, a 11/32 in. handle movement, and 2½ oz weight. When a particular application calls for extra fine metering a "Micro Meter Thread", with 40 threads to the inch, can be specified. These angle needle valves are available with any desired usual combination of standard pipe connections.

Kohler Co., Kohler, Wis.

Valve Has Ceramic Body to Handle Corrosives

Diamond-hard ceramic body and valve stem handle highly corrosive fluids at high pressures.

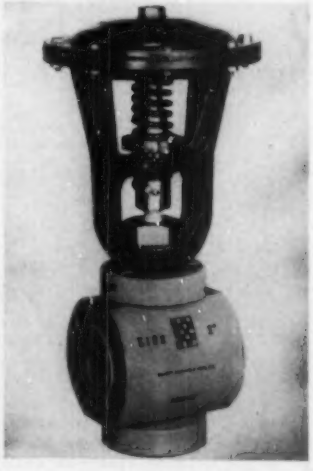
This valve incorporates a body made of a newly developed "Merit Ceramic" and is suitable for continuous 300 psi operation. It will withstand temperatures up to 2,000 deg F and control the flow of highly corrosive gases and concentrated or diluted chemicals, with the exception of hydrofluoric acid and hot alkali concentrate.

Valve bodies are machined from a solid slug of the new ceramic prior to final firing. The finished body has a hardness 9/10ths that of a diamond, with tensile strength of 27,000 psi, compressive strength of 290,000 psi, specific gravity of 3.63, and modulus of elasticity of 40,200,000. In addition, it will not absorb moisture.

The valve stem is also fabricated from "Merit Ceramic", and alternate hard and soft "Teflon" packing rings are incorporated as seals. These valves are available in ¼, ⅜, 1, 1½, 2 and 3-in. sizes at present. They are designed for attachment to 300-pound standard ASA flanged fittings by means of stainless steel cap screws. Stainless steel studs can be permanently mounted in the valve body if desired. Both diaphragm and hand-operated types (lubricated or unlubricated) are available.

These new ceramic valves follow the same design principles found in the company's standard valve line. They should be useful in any application where corrosive fluids must be handled under conditions of high temperature and pressure without valve damage.

Emmett Machine & Mfg. Co., 2249-27 Fourteenth St., S.W., Akron 14, Ohio



CONTINUED ON PAGE 166

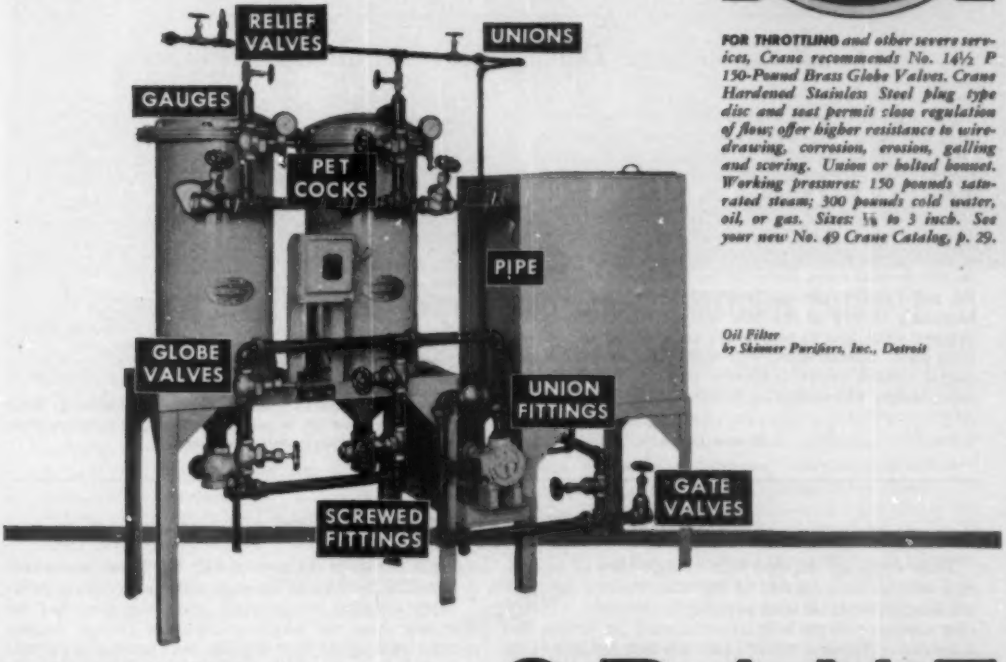
The easy way to specify piping is to specify piping from CRANE

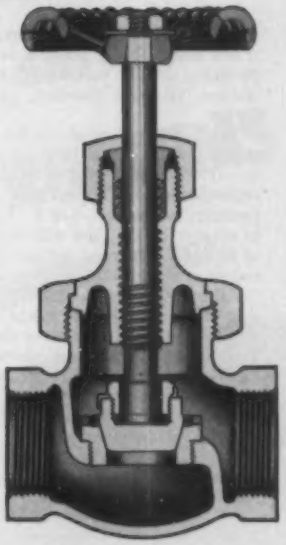
That's because Crane manufactures the world's most complete line of quality valves, fittings, pipe and accessories. This vast assortment of equipment is carefully arranged—in one catalog—for your quick selection. Whether you're designing an *Oil Filter,* as shown here, or something more simple . . . or complex . . . you'll find all the piping materials you need in the Crane Catalog.

All other piping procedures are simplified, too, when you rely on Crane. Final product assembly work is smoother . . . buying and storekeeping become easier. And, above all, your product acquires added value because it is Crane equipped. Buyers know from experience that Crane Quality in piping equipment has never been surpassed.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

FOR COMPLETE SELECTION . . . BETTER PIPING LOOK ALWAYS TO THE BROAD CRANE LINE





FOR THROTTLING *and other severe services, Crane recommends No. 14½ P 150-Pound Brass Globe Valves. Crane Hardened Stainless Steel plug type disc and seat permit close regulation of flow; offer higher resistance to wire-drawing, corrosion, erosion, galling and scoring. Union or bolted bonnet. Working pressures: 150 pounds saturated steam; 300 pounds cold water, oil, or gas. Sizes: ⅛ to 3 inch. See your new No. 49 Crane Catalog, p. 29.*

Oil Filter
by Skinner Purifiers, Inc., Detroit

EVERYTHING FOR EVERY PIPING SYSTEM

CRANE

VALVES • FITTINGS • PIPE • PLUMBING AND HEATING

New Silicone Rubber is Made in Variety of Shapes

The new X-6 Silicone rubber, which is especially useful at low temperatures, can now be furnished in gaskets, diaphragms, sleeves, packings, channel, and numerous other molded, extruded, punched, and die or lathe-cut rubber shapes.

The brittle points of the low temperature X-6 Silicone stocks, measured on ⅛-in. thick sections, range from —150 to —170 F. Rubber parts fabricated from these stocks are recommended for applications involving continuous temperatures as low as —110 F. Silicone rubbers are resistant to sulphur dioxide and will withstand the chemical action of liquid ammonia and certain types of Freon used in refrigeration systems.

All other properties of X-6 Silicone rubbers are comparable to those of former stocks. These versatile synthetics are resistant to oils and many chemicals, and, especially, to permanent compression at elevated temperatures. Silicone rubber parts are suitable for both high and low voltage applications. They have greater resistance to ozone than any other elastic material and feature excellent water repellency. Silicone rubbers also have many applications in x-ray, radio, radar, television and other electronic and electrical equipment in which heat stability and high surface resistivity are of primary importance.

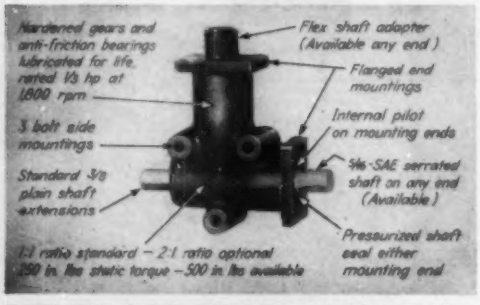
TYPE X-6 SILICONE RUBBER is now available in molded, extruded, punched, and die or lathe-cut shapes. Typical shapes are shown above to illustrate some possible applications.

The Stalwart Rubber Co., 166 Northfield Rd., Bedford, Ohio

Small Right-Angle Drive Features Improved Mounting

The new ANGLgear unit includes a rectangular, 4-hole mounting flange with an internal pilot on both ends of the housing. These mounting arrangements are in addition to the 3-hole side mounting originally employed. The unit is further modified to make available 2-1 reduction as an optional extra feature in addition to the standard 1-1 ratio. The standard unit is rated at 250 in. lbs static torque capacity or to transmit ¼ hp at 1,800 rpm continuous duty. As an optional extra units can be furnished with 500 in. lbs static torque rating. Incorporation of the Universal Mounting feature in the new design reduces the models required from four to two, which are available for delivery from stock. Special units, with shaft extensions made with special splines, keyways, squares, etc, will suit customer's requirements when adapting to existing equipment.

Airborne Accessories Corp., 25 Montgomery St., Hillside 5, N. J.


Hardened gears and anti-friction bearings lubricated for life, rated ½ hp at 1800 rpm
3 bolt side mountings
Standard ⅜ plain shaft extensions
1-1 ratio standard — 2-1 ratio optional
250 in. lbs static torque — 500 in. lbs available
Flex shaft adapter (Available any end)
Flanged end mountings
Internal pilot on mounting ends
⅜s-SAE serrated shaft on any end (Available)
Pressurized shaft seal either mounting end

THREE WAY RIGHT ANGLE DRIVE is illustrated. Note that the drive shafts can be provided with either a flexible shaft fitting or a SAE serrated shaft on any end.

Blind Rivet Is Hammer Driven

These rivets are installed with a single blow of an ordinary hammer in a fraction of the time required for other attaching methods. It is an assembly of two parts; a hollow rivet member with the hole tapered toward the bottom, and a serrated drive pin assembled part way into the hole in the rivet. The end of the rivet shank is slit longitudinally to facilitate splitting.

These rivets are installed with a hammer blow that forces the pin to spread the inner tapered section and separate the split section of the rivet shank. The blind head which is formed at the back of the work makes a permanent joint.

Easily installed by unskilled labor, this rivet has the necessary shear and tensile strength for average requirements. Other types of rivets, for such unusual conditions as high shear load, excessive vibration, or abnormal tensile forces, have the same principle of operation.

Cherry Rivet Co., Los Angeles, Calif.

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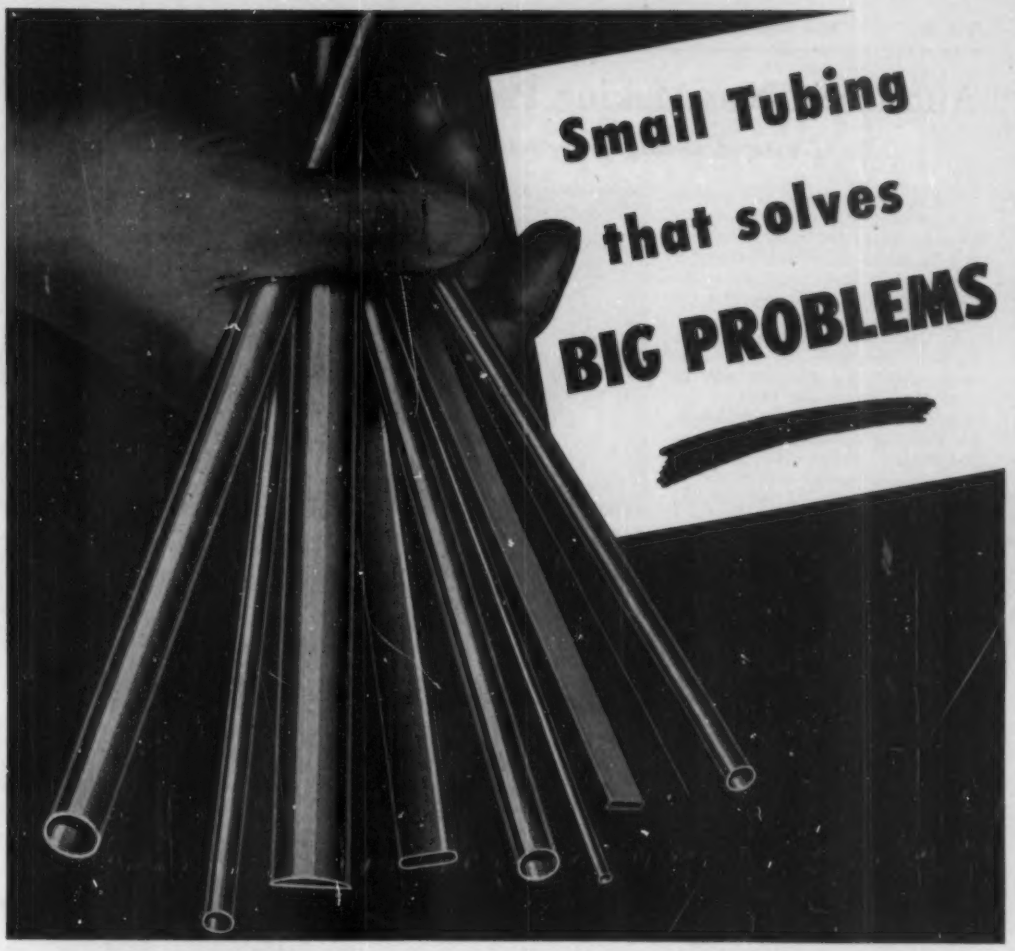


SEAMLESS NON-FERROUS TUBING THAT MAKES PRECISION POSITIVE!

Increased strength . . . reduced weight . . . improved finish . . . greater durability . . . that's how PRECISION seamless tubing enables you to improve your product.

And, no matter what shape you want tubing drawn—round or rectangular, oval or square—PRECISION can supply it.

How about alloys? *All alloys* (including those hard-to-work) *are drawn with ease* into tubing as small as a hair or big as your thumb by Precision Tube Company: 0.500″ to 0.010″ O.D.; wall thicknesses down to 0.0015″.

You'll find that practically every type of industry in the country is improving the design and performance of its products through the use of PRECISION tubing. It's being used in bourdon gauges, mechanical pencils, watch pinions, ball-point pens, automobile antennas, instrument pointers—wherever precision-made tubing is required.

Prompt deliveries, too!

For full information on tubing that is outstanding for its mechanical properties and finishes, write: Precision Tube Company, Inc., Dept. A, 3824 Terrace Street, Phila. 28, Pa.

WHEN PRECISION COUNTS . . . COUNT ON PRECISION

PRECISION TUBE COMPANY, INC.

Automatic Nut-Making Process Simplifies Assembly

Specially shaped, thread-engaging holes are multiple-punched in sheet metal assemblies.

Called "Prestalizing", this method is a patented process for punching a specially shaped nut in sheet metal up to ¼ in. thick. All of the usual sheet metals can be used, including aluminum, mild steel, stainless steel, or brass.

In practice, the design engineer specifies "Prestalize for 10A sheet metal screw", for example, and the production department provides any number of integral fasteners by a simple stamping operation. This means that separate fasteners need not be procured, stored, handled or applied.

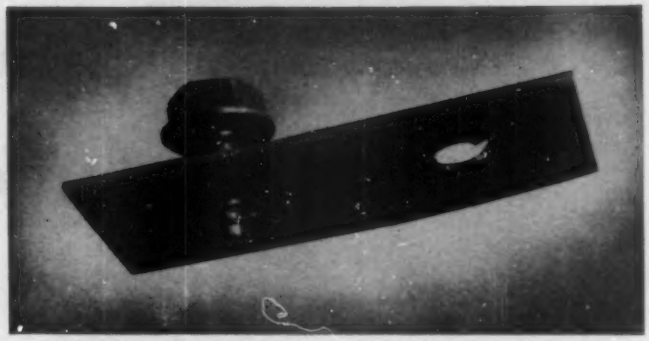
In operation, special punches and dies (supplied by the company) pierce the metal and form it to a helical shape conforming to the pitch of the screw thread. The shaped nut gives a full 360 deg grip on the thread, and makes a much stronger than usual fastener. Any number of separate "nuts" can be stamped in the same operation. Since holes usually have to be stamped anyway, regardless which fastener is used, there is no duplication of operations.

In applications where the product will be enameled, standard Prestole tools are used in the hydraulic press. The tools compensate for enamel build-up and the impressions do not fill with enamel or require wiping, nor do they cause crazing or chipping when screws are tightened into them.

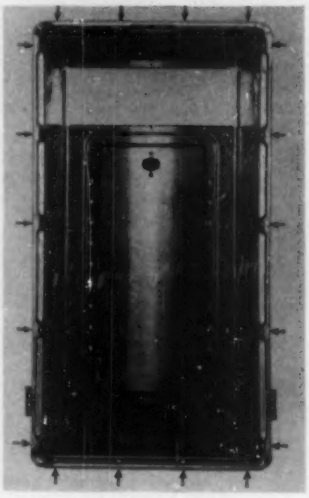
The versatility of the Prestole fastening method will appeal particularly to design engineers. There is a choice of stamping the thread grip directly into the structure or into structural parts, or using separate Prestole fasteners, depending on the requirements of each fastening job.

This process is handled on a license basis, with the company furnishing the special tools that can be adapted to any press production line. Engineering service is provided to determine whether the process is applicable to the product. For applications where the fastener must "float" slightly to make up for unavoidable misalignment, a special fastener, that clips to the assembly, can be supplied. Having already been adopted by the automotive, refrigeration and radio industries, the Prestolixing method will now attract the attention and interest of design engineers in other industries using sheet metal in the fabrication of their product.

Prestole Corp., Toledo, Ohio



HOLE IS PUNCHED and fastener formed in one operation. Notice how the formed "nut" supports one complete thread for a full 360 degrees. These fasteners can be punched in any sheet metal, including aluminum, spring steel, mild steel, and brass or bronze. A number of these fasteners are usually punched at once.



REFRIGERATOR LINER has 22 Prestolized fasteners. They are all punched in one operation, with a standard hydraulic punch. Punching is done in the flat sheet, before the liner is formed. After the liner is enameled screws can be tightened into the Prestole fastenings without chipping or crazing the enameled surface.

Photosensitive Drawing Cloth Need No Negative

The conventional negative step used in making cloth reproductions of engineering drawings can be eliminated by the use of Kodagraph Autopositive Cloth. Like other "Autopositive" materials, Kodagraph Autopositive Cloth produces a positive copy directly from a positive original drawing. It may be handled in normal room light and is exposed on conventional blueprint or direct-process machines or a vacuum printing frame.

The new cloth is highly translucent, assuring rapid production of quality shop prints, and may be drawn in on either side, using ink or pencil. It is available in 30- and 100-foot rolls in the following standard widths: 20, 30, 36, and 42 inches.

Eastman Kodak Co., Rochester 4, N. Y.

CONTINUED ON PAGE 170

Tapered-Twisted Teeth

FOR MAXIMUM LOCKING EFFICIENCY

WHEN YOU ORDER SEMS, BE SURE TO SPECIFY SHAKEPROOF LOCK WASHERS!

SHAKEPROOF

T. M. REG. U. S. PAT. OFF.

LOCK WASHERS

a type and size for every locking need!

"FASTENING ANALYZED"

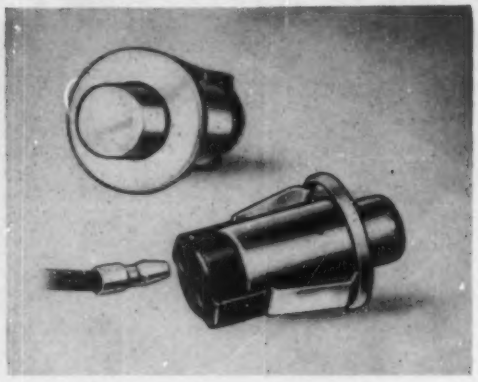
SHAKEPROOF inc.

Pushbutton Switch Features Quick Assembly

Installation costs can be greatly reduced with this snap-in type switch. It is simply pressed into a $\frac{7}{8}$ in. punched hole and held securely by two expansion springs. These springs have a sufficient range for panels of 0.030 to 0.050 in. thick. In addition, this switch uses plug-in electrical wire terminals. The combination of these two features, makes it possible for one to connect and mount this switch within 15 seconds, according to the manufacturer.

The No. 7712 switch is a momentary contact device which is normally closed and requires $\frac{1}{8}$ in. of push-button motion to open the circuit. This switch has SPST contacts and is rated at 1 amp.—125 v ac. The switch body consists of molded phenolic and the exposed metal parts are cadmium plated. The overall length of the switch is 1 9/16 in. and the flange diameter is 1 inch.

Ark-Les Switch Corp., 51 Water St., Watertown 72, Mass.

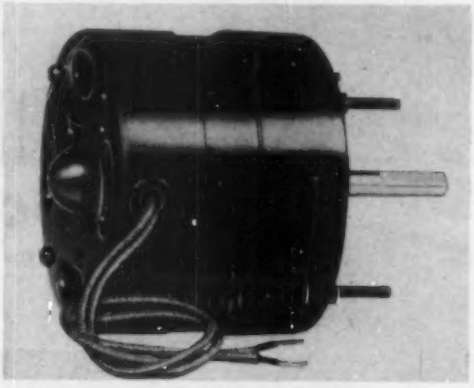


New Line of Shaded Pole Motors is Produced in Three Styles

Available in three frame styles, these four pole shaded pole induction motors have power ratings varying from 1/10 to 1/60 hp at 1,550 rpm. One model has a drawn steel housing, another a die cast housing with resilient mounting, and the third a unit bearing construction. The last named, with unit bearing construction, is made in two types: one for horizontal or shaft up applications and the other for horizontal or vertical shaft down applications. These motors should be especially useful for refrigeration and air conditioning applications, and all air moving devices.

The three general types are: type 330-S, with ratings from 1/20 to 10 hp, and with die cast rotors and self aligning porous bronze bearings; type 330-C and 330-CB, with die cast shields and a resilient mounting (other specifications similar to type 330-S); and type 330-U and 330-UX, both having sealed lubrication with babbit bearings.

Russell Electric Co., 4501 S. Western Blvd., Chicago 9, Ill.



O-Rings Are Injection Molded From Synthetic Rubber

A new synthetic rubber compound has been injection molded to produce a rubber "O" ring with fine tolerances. This synthetic rubber compound has special characteristics which give high resistance to oil swelling and abrasion. Its high tensile strength makes it suitable for high hydraulic pressures. Although O-rings are generally restricted to sealing oil pressures of 3,000 psi, the manufacturer has made several installations in which O-rings have been used at 10,000 psi with good results.

The O-ring type of seal has been used extensively for shaft and piston seals on reciprocating machinery. The ease of installation and simplicity of design has enabled industrial designers to reduce machinery and assembly costs considerably over the old type of hydraulic seals.

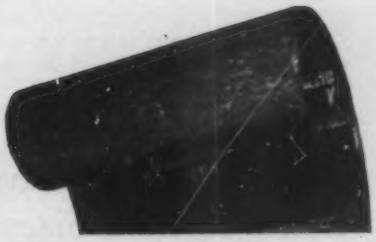
These factors should always be considered when designing with O-rings:

1. O-rings may be used alone as a moving seal up to 1,500 psi, and up to 3,000 psi with leather back-up rings.
2. Cord rings may be used as static seals up to 5,000 psi without using back-up washers.
3. Never install more than one O-ring on the same shaft because of pressure build-up between the two rings.

Minnesota Rubber and Gasket Co., Woodale Ave., Minneapolis 16, Minn.

CONTINUED ON PAGE 172

K-68...



the outstanding gasket material for refrigeration equipment... for use in hot oil, gasoline, naphtha, and all petroleum fractions.

In refrigeration equipment... in gasoline and diesel engines... in refineries... in pumps handling gasoline or other petroleum fractions, K-68 Compressed Asbestos Sheet Packing insures long-lasting, trouble-free gaskets.

This unusual gasket material was perfected originally for use on aircraft engines, where the expansion and shrinkage of hot metal parts presented a serious problem. It is now available for use wherever the designer must overcome the combination of heat and aromatic oil products. As it contains no sulphur, it is also widely used in refrigeration equipment.

K-68 retains its resilience after long immersion in hot oil, and meets Specification AMS-3232. It is also on the approval list of Specification AN-G-171. It consists of selected asbestos fibres, bonded with Neoprene only, under high pressure. Write for full specifications or for information on other R/M packings.

RAYBESTOS-MANHATTAN, INC.

PACKING DIVISION, MANHEIM, PA.

FACTORIES: Bridgeport, Conn. · Manheim, Pa. · No. Charleston, S.C. · Passaic, N.J.

RAYBESTOS-MANHATTAN, INC., Manufacturers of Packings • Asbestos Textiles • Mechanical Rubber Products • Abrasive and Diamond Wheels Rubber Covered Equipment • Brake Linings • Brake Blocks • Clutch Facings • Fan Belts • Radiator Hose • Powdered Metal Products • Bowling Balls

R M

RAYBESTOS-MANHATTAN, INC. P-40
Packing Division, Manheim, Pa.

Gentlemen: Please send me data on K-68.

Name _____

Position _____

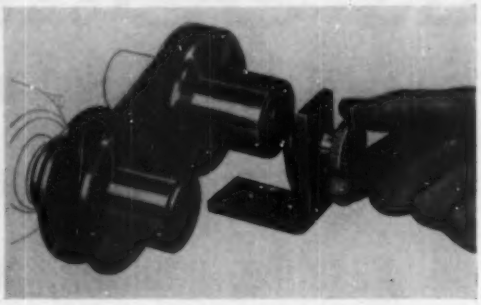
Company _____

Address _____

City _____ Zone _____ State _____

Variable Speed Combination Sheaves Come in Five Sizes

New sizes cover a range of load capacities up to 7½ hp, with up to 7:1 speed ratios.

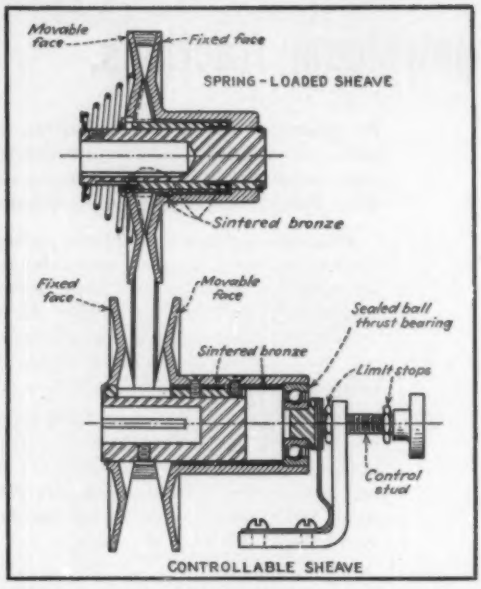


"Speed Selector Combination Sheaves" are simple mechanisms for producing wide variations of speed between fixed-center shafts through use of standard V-belts. The 3, 4, 5, 6 and 7 in. single-groove sizes are each available in two types: spring-loaded and controllable. This makes it possible to combine small driving sheaves with larger driven sizes for low speed requirements, or to use large driving sheaves with smaller driven sizes for high speed ranges. Many combinations are possible, covering an extremely wide range of speed and load capacities. The new 8 in. size, built with double grooves, is designed for the larger horsepower requirements, and cannot be combined with smaller single groove sizes.

The spring-loaded variable-pitch driving sheave is usually mounted on the motor shaft, and the controllable pitch sheave, of either the same or a different diameter, is mounted on the driven shaft. The control knob and bracket assembly furnished is then secured to the machine base, and the standard V-belt snapped into place to complete the drive.

As the faces of the controllable sheave are forced closer together, the pitch diameter at which the belt rides in its V-groove is increased. This pulls the belt deeper into the groove of the spring-loaded sheave, spreading its faces apart and producing a smaller driving pitch diameter. Thus the pitch diameter of one sheave is decreased as the other pitch diameter is increased. This multiplies the speed variation of one sheave by the speed variation of the other, resulting in unusually wide total speed variations as high as 7:1. Sheaves can be mounted on fixed shaft centers either widely spaced or close together, eliminating the need for sliding motor bases, moveable jackshafts or special wide, high-cost belts. Since opposite faces of the two sheaves are moved, correct belt alignment is maintained at all speeds.

Speed Selector Inc., 118 Noble Court, Cleveland 13 ,Ohio



WHEN THE CONTROL KNOB bears against the thrust bearing the two faces of the controllable sheave are forced together, to make the V-belt ride on a larger diameter.

New Hot-Work Tool Steel Has Excellent Hot-Hardness

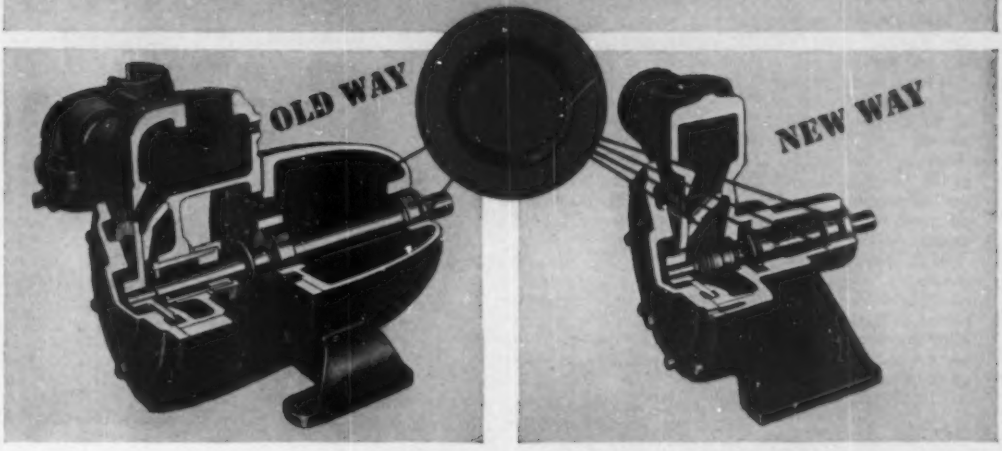
This new tool steel has demonstrated remarkable qualities such as: excellent hot hardness, and very good resistance to washing-out or changing size. Called the B-47 Hot-Work Steel, it has been recommended for use in extrusion dies, hot-punch tools and forging dies. This steel has been released after out-performing several other alloy steels during an extensive testing period. The B-47 steel is a chromium-tungsten-cobalt-vanadium steel which can be either oil or air quenched. The drawn hardness at 1,000 deg F is over 60, Rockwell C scale; after 2 hours of drawing at 1300 F, the hardness is 43 C Rockwell.

This steel has the following physical properties at 1200 F when data is based on specimens of Rockwell C 45 hardness: Short-time ultimate tensile strength—110,000 psi; elongation—16.5 percent (2 in.); reduction of area—37 percent; brinell hardness—241. The average impact strength (Charpy V notch) is 8¾ ft lb with standard test specimens of 50½ Rockwell C hardness.

Allegheny Ludlum Steel Corp., Pittsburgh 22, Pa.

CONTINUED ON PAGE 174

REDESIGN TRIMS LENGTH 5¼ INCHES, CUTS UNIT COST $5.70



Series D Wayne water pump uses machined shoulders to position bearings on shaft. 2 Truarc rings hold bearings in housing. Locknut holds screw-type stuffing box that requires periodic tightening.

New design uses 4 Truarc Inverted rings (2 external, 2 internal) to position shaft, retain bearings. Inverted rings provide shoulders of uniform section height. 1 Standard ring secures maintenance-free mechanical seal.

Redesign with Truarc Rings helps save $5.70 per unit for Wayne Home Equipment Company, Inc., Fort Wayne, Ind. It gives them a more compact product, eliminates a separate bearing pedestal and a skilled-labor grinding operation. It facilitates use of maintenance-free mechanical seal instead of old type stuffing box.

Redesign with Truarc Rings and you too will cut costs. Wherever you use machined shoulders, nuts, bolts, snap rings, cotter pins, there's a Truarc Ring that does a better job of holding parts together.

Truarc Rings are precision engineered. Quick and easy to assemble, disassemble. Always circular to give a never-failing grip. They can be used over and over again.

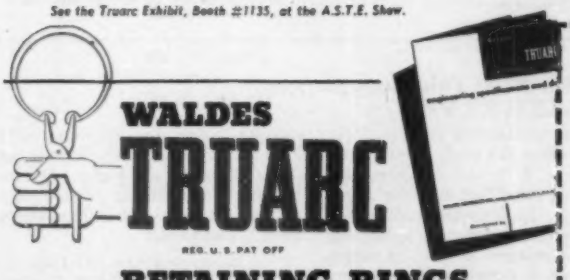
Find out what Truarc Rings can do for you. Send your blueprints to Waldes Truarc engineers for individual attention, without obligation.

See the Truarc Exhibit, Booth #1135, at the A.S.T.E. Show.

REDESIGN WITH 5 TRUARC RINGS GIVES THESE BIG SAVINGS

- *Cuts length 5¼ inches*
- *Cuts total labor 15.3%*
- *Eliminates skilled-labor grinding operation*
- *Saves 38.3% materials*
- *Allows use of stock-size shaft, smaller bearings*
- *Eliminates separate bearing pedestal*

TOTAL UNIT SAVING . . . $5.70



WALDES TRUARC

REG. U. S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS ARE PROTECTED BY U. S. PATS. 2,000,048; 2,088,484; 2,418,852 AND OTHER PATS. PEND.

Waldes Kohinoor, Inc., 47-16 Austel Place PN 042
Long Island City 1, N. Y.

Please send 28-page Data Book on Waldes Truarc Retaining Rings.

Name_____

Title_____

Company_____

Business Address_____

City_____ Zone_____ State_____ ★

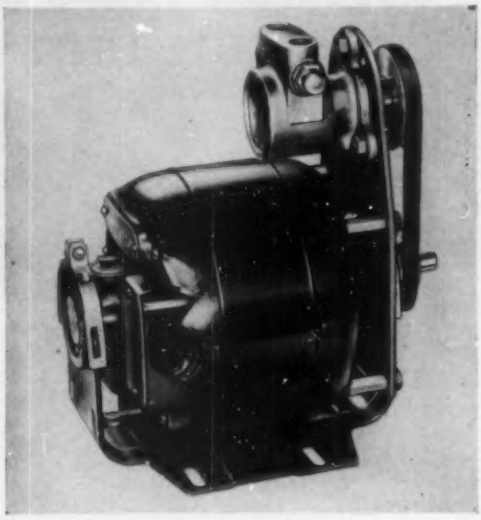
Small Pump Handles Corrosive Liquids

Made for wide usage in the drink vending machine field, the "Procon" pump will also handle water, oil, gasoline, fuel oil, and many of the common chemicals.

It has a vane type positive displacement construction, and will operate at pressures of 200 psi, with pump capacities up to 60 gph. Since there is metal-to-metal contact of moving parts, the unit is extremely quiet and pulsationless. Units can be run dry for hours without harm. Incorporated in the pump is a relief valve which can be set for any desired pressure. Fluid can also flow directly through the pump when it is not in operation. Standard models have a vacuum pull of 26 in. of mercury.

With the belt-driven pump any standard ¼ hp motor can be used. Pumps can be mounted to the right or left or vertically on top of the motor, or they can be directly connected to the motor or machine drive shaft. In disassembling the unit it is only necessary to remove two snap rings and the unit falls apart. There are no nuts, bolts, or gaskets or other such parts to bother with.

Procon Pump and Engineering Co., 1600 E. Eight Mile Rd., Detroit 3, Mich.



Variable Transformer Has Been Redesigned

Improved design features of the "Powerstat" mean greater strength, more convenience and longer service. The use of a die-cast aluminum terminal box and a phenolic-plastic terminal board has added greater strength and prevents breakage. These transformers come in two types: 116 and 216. Type 116 is rated at 115 volts, 50 to 60 cycles from 0 to 135 volts and 7.5 amp. Type 216 has an output of 0 to 270 volts, 3.0 amp from 230 volts, 50 to 60 cycles, single phase input.

A new fusing arrangement is employed on the cord-plug models. A twist-lock holder on the side of the terminal box gives easy access and simple replacement. Solder-screw terminals are arranged for better spacing and for quicker and more positive connections. Barriers between terminals reduce short circuit hazards. A heavy-duty "on-off" switch is in a convenient, easy-to-reach position.

Superior Electrical Co., Hannon Ave., Bristol, Conn.

STREAMLINED TRANSFORMER is fully accessible: fuse, plug-in terminal, switch, and control are all within easy reach.

DC Relay Has Multi-Pole Construction

With an operating time as short as ¼ millisecond, this hermetically sealed dc relay is now offered in 6-pole, double throw construction. This type of relay is usually single-pole, double-throw, or double-pole, double-throw. Use of a 20-pin hermetically sealed header and a 20-pin octal socket makes the 6-pole construction possible.

A complete line of multi-pole relays includes 3, 4, 5, and 6-pole models, all double throw, all with the 20-pin octal base. An important construction feature is a shock absorbing mechanism which eliminates bounce. Contacts usually use dc power; ac is not recommended except for millivolt, milliampere applications. The contact rating is 100 v, dc, and ½ amp. Life expectancy varies from 22 million operations at ½ amp, to 100 million operations at ¼ amperes.

Stevens-Arnold Inc., 22 Elkins St., South Boston 27, Mass.

CONTINUED ON PAGE 176

SEALMASTER
BALL BEARING UNITS

Put Better Bearing Performance In Your 1950 Sales Picture

Make *sure* that the bearings you use are a sales asset to your product . . . and make them a prominent part of your sales story! Many leading manufacturers have improved both their product and its sales effectiveness with SealMaster Ball Bearing Units.

SealMasters offer a combination of advantages found in no other bearing. The complete line includes every type and size to meet any requirement. Call in the SealMaster engineer . . . let him show you how SealMasters can improve your product at no extra cost. There's a catalog available containing complete details . . . write for it today.

5 Reasons Why SealMasters Improve Your Product

1. Permanently Sealed
2. Self-Aligning
3. Prelubricated
4. No Housing Wear
5. Floating Retainer

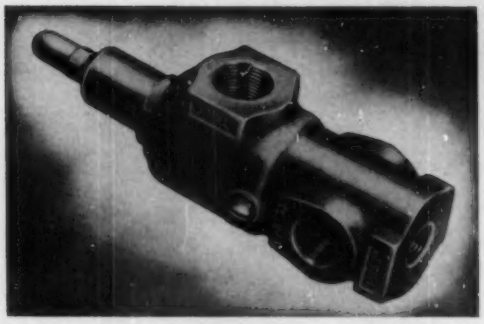
Bearing Division
STEPHEN S-A ADAMSON MFG. CO.

9 Ridgeway Avenue, Aurora, Illinois • Los Angeles, Calif. • Belleville, Ont.

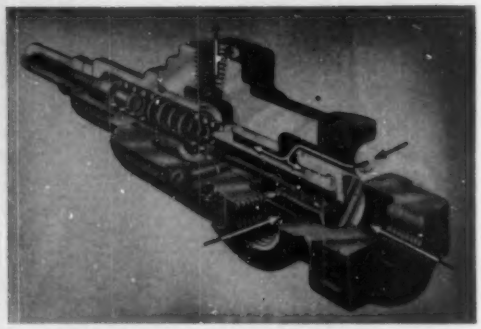
FACTORY REPRESENTATIVES AND DEALERS IN PRINCIPAL CITIES

Adjustable Relief Valve is For High-Pressure Service

A new differential piston design allows the use of a light spring, which gives close control and full flow with no valve chatter.



DESIGNED FOR USE WITH high-pressure oil-hydraulic control systems, this new relief valve is available in capacities ranging from 5 to 80 gpm. Operating pressures range from 400 to 1650 psi. Three valve sizes have pipe connections of ¾, 1½, and 2 in., which handle a maximum flow of 15, 50, and 80 gpm, respectively. The pressure connections on opposite side and on the bottom are optional. A differential piston arrangement permits full flow with no valve chatter.



MAIN FEATURE OF THE VR SERIES RELIEF VALVE is the differential piston design, which allows the use of a lighter spring and gives close control. When oil enters one of the ports under high pressure, it fills a chamber, exerting pressure in all directions. The plunger has a piston on each end and since the poppet end is only slightly larger in area, a light spring is sufficient to balance the pressure. This light spring tends to dampen rapid-valve motion and eliminate valve chatter.

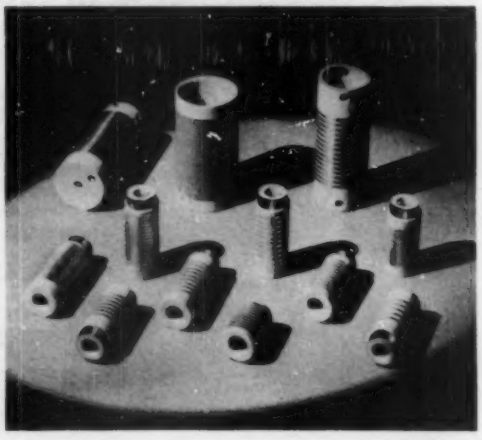
Hydraulic Equipment Co., Cleveland 17, Ohio

Metallized Winding Replaces Wire On Coil Forms

Instead of the usual wire winding these coils have the winding metallized directly to the coil form.

When wire is wound around a coil form, there is some air space between the wire and the ceramic. As heat is generated, the difference in the expansion factors of the wire and the ceramic will aggravate this condition. The result is an unstable coil, the inductance of which may not retrace to the original value. In the new method a spiral metal coating is fired on the ceramic, assuring intimate contact. The thin metal layer follows elastically the dimensional thermal changes of the ceramic which are far lower than those of any of the commonly used metal wires. Inductances of this type are therefore ideally suited for precision tuning circuits. To cite definite values: The inductance coefficient of AlSiMag 196 coil form, wound with copper wire, is 40×10^{-6}/deg C. For an identically shaped coil form of the same material, but with the metal fired on the ceramic, it is only 18×10^{-6}/deg C. For the coil form, any of the vitreous low loss AlSiMag compositions can be used. The selection of the material is governed by the individual application.

Metallizing is also developed for individual requirements. Multiple threading is readily furnished. Metallized sections suitable for soldering direct to chassis can be made an integral part of the particular product design.



A METALLIZED STRIP replaces the usual wire winding. The thin metal layer follows the dimensional thermal change of the ceramic, giving an electricity stable oil.

American Lava Corp., Chattanooga 5, Tenn.

CONTINUED ON PAGE 178

Let's help you find the tube you need

Here, in full-size cross section, are a few of the thousands of seamless Special Shape Tubes we've made. Some were produced to the usual commercial tolerances and finishes for such applications as electrical fixtures, furniture ferrules, heat exchangers, radiator tubes, refrigerator controls, hardware, jewelry, automatic pencils, etc., etc. Others were precision-made tubes for industrial and scientific purposes, unusually accurate in I.D., O.D. and surface finish, inside and out.

We have a large variety of stock tools which could save you tooling-up charges. Send us a sample, drawing or description of the tube you need, together with quantity and other pertinent information, and we'll be glad to quote on your requirements and to your specifications.

Anaconda Special Shape Tubes are available in Copper, Brass, Bronze, Nickel Silver, Special Copper Alloys and Aluminum, furnished in straight lengths or accurately cut to specified size. Write to The American Brass Company—French Small Tube Branch, Waterbury 20, Conn. 49297

ANACONDA

SPECIAL SHAPE TUBES

by the makers of Anaconda Bourdon Tubes, Thermal Expansion Bulbs and Copper Dehydrated and Cup-Sealed Refrigeration Tubes

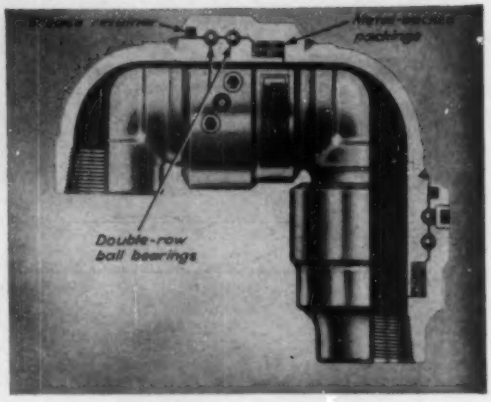
Swivel Pipe Coupling Uses Ball Bearings

The "All-Flex" swivel pipe coupling has been designed to transmit fluids at high pressure thru a joint which can rotate 360 degrees in all planes. Both the synthetic packing and metallic seals insure protection against leakage at very high pressures. A double row of ball bearings are used to lock the ports together and also maintain the lowest possible resistance to rotation. The ¾ in. coupling requires less than 10 in. lbs at 3,000 psi. The coupling can operate at an average speed of rotation up to 60 rpm and the synthetic packing normally used permits operation at temperatures up to 225 Fahrenheit.

This type of swivel pipe coupling has two hardened and ground steel bearing races in each joint. These ball bearings insure proper joint alignment and keep the torque required for rotation to a minimum. It is compact and streamlined throughout with no projections; there are no bolted-flanges, locking rings or threaded sleeves.

"All-Flex" couplings are divided into high and low pressure groups. The high pressure coupling is designed for use up to 1,200 psi. In the low pressures these fittings come in malleable iron, steel, bronze or aluminum.

Gil-Lair Products, Inc., Pasadena, Calif.



STREAMLINED SWIVEL PIPE COUPLING can transmit fluids up to 12,000 psi. Little torque is required to rotate pipe because of the double-row ball bearings.

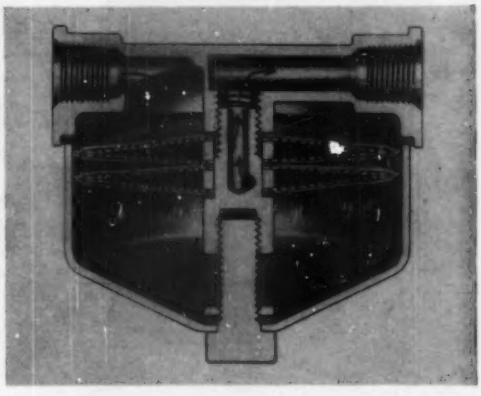
Filter Has Large Effective Area, Compact Size

This new device is recommended for separating solid particles as small as 1 or 2 microns from liquids or gases. It may be used to separate water from gasoline or fuel oils, or to remove oil from water or air. Gases may also be purified with this unit.

The filter attains a large effective area within a small space by using a series of V-shaped filter disks. These disks are covered with various filter media, such as synthetic rayon non-woven cloth, resin treated filter paper, or woven wire cloth, providing a very wide range of porosity and degree of filtration. A single bolt secures the disks in the housing and makes cleaning or replacement simple.

The filter housing is made of cast aluminum and all exposed parts are rust proofed. Filters can be obtained in sizes and capacities to meet every requirement. The manufacturer emphasizes that the product has been designed for mass production in order to maintain a low price.

Sparkler Mfg. Co., Mundelein, Ill.



Solenoid Operated Valve Prevents Water Hammer

By slowing the closing action of the valve from 1½ to 2 seconds, water hammer is eliminated from high velocity pipe line systems. This delayed action is produced by a dash pot connected integrally to the poppet valve stem. The provision of a simple ball-check valve in the dash pot insures rapid valve opening. The new direct-operated solenoid valve is available for normally closed operation and is built for heavy duty service. It has no auxiliary pistons to expose close tolerances to silt laden liquids. It handles temperatures up to 400 F, and smaller sizes will operate under differential pressures up to 150 lbs. Solenoids are rated to provide unusual reserve factor. The body is bolted together for maximum strength, and for easy access to all operating parts. Valve seats are stainless steel. The valves are available in ⅜, 1, 1¼, 1½ and 2 inch sizes.

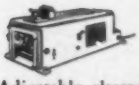
Johnson Corp., Three Rivers, Mich.

CONTINUED ON PAGE 180

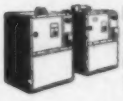
First—Baldwin-Sonntag fatigue and simulated-service testing machines filled a gap in the designer's knowledge of essential properties of machine elements and engineering materials. Now—this newest machine fills a gap in the capacity range, completing a line that permits application of forces varying from 20 lb. to 20,000 lb.

The new SF-10-U provides for static pre-loads up to 5000 lb., accurately maintained throughout the test, plus a maximum of 5000 lb. alternating load, applied at a frequency of 1800 cycles per minute. Maximum amplitude is ½". The same *constant force* principle is used as in other SF machines.

Full information on the SF-10-U or on the other units in the Baldwin fatigue testing line shown below will be furnished on request.

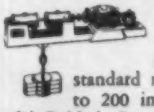


BALDWIN-SONNTAG SF-2 FATIGUE TESTING MACHINE. Small, light motor-driven unit for bench mounting for testing sheet materials in flexure. Adjustable alternating force up to 20 lb. (Bulletin 256)



BALDWIN-SONNTAG SF-01-U and SF-1-U UNIVERSAL FATIGUE TESTING MACHINES. For testing materials or parts in tension, compression, torsion, bending or combined stresses. Maximum force—SF-01-U, 200 lb.; SF-1-U, 2000 lb. (Bulletin 258)

BALDWIN-SONNTAG SF-20-U UNIVERSAL FATIGUE TESTING MACHINE. Maximum force 20,000 lb.—48 inch distance between platens—large permissible amplitude. (Bulletin 257)



ROTATING BEAM FATIGUE TESTING MACHINES. (1) R. R. Moore using standard machined fatigue specimens stressed up to 200 in. lb. at 10,000 R.P.M. (Bulletin 204). (2) Baldwin-Sonntag SF-10-R—standard specimens up to 1" diameter, capacity 10,000 in. lb., 3600 R.P.M. (Bulletin 259)

OTHER BALDWIN FATIGUE TESTING EQUIPMENT. The Baldwin line includes a number of special fatigue testing machines, such as the Lazan Oscillator, the Rolling Load Fatigue Machine, the BF Fatigue Machine, Vibration Tables, and others. If you have any special problems, ask about this special equipment.

The Baldwin Locomotive Works, Philadelphia 42, Pa., U. S. A. Offices: Chicago, Cleveland, Houston, New York, Pittsburgh, San Francisco, St. Louis, Washington. In Canada: Peacock Bros., Ltd., Montreal, Quebec.

BLW THE BALDWIN GROUP

BALDWIN

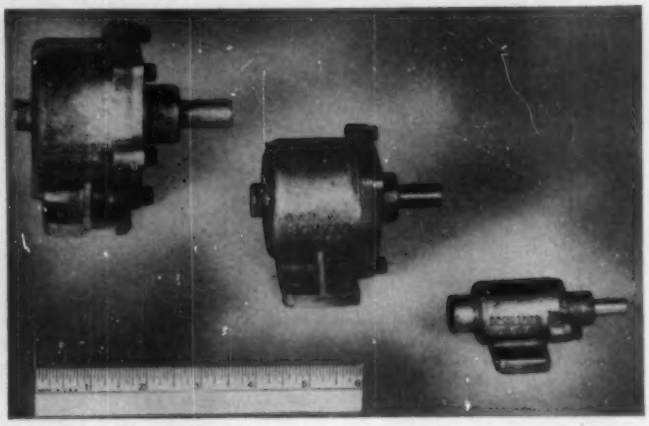
TESTING HEADQUARTERS

7794

Small Size Cylinders Can Be Used as Air Clamp

A complete line of bantam-sized air cylinders is now being produced for industrial applications where small and powerful air clamps are required. These cylinders are of the push-type and have a spring return. Two styles are made to facilitate mounting in either a vertical or horizontal position. The housing is made of cast brass and features easy service and replacement. These cylinders have either a 1 or 2 in. stroke length and a bore diameter of 1, 2¼ and 3 inches.

In addition, a small three-way air valve has been designed for use with the small air cylinders. This valve consists of a precision-lapped stainless steel disk which slides on a bronze ring for positive and air tight sealing. It has a capacity of 10 cu ft per min at 100 pounds pressure. Valves can be either mechanically or manually operated, depending on application.

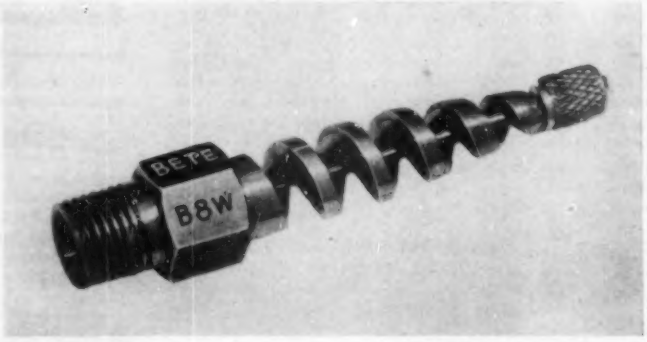


BANTAM-SIZE AIR CYLINDERS are made in three sizes shown: 1, 2¼ and 3 in. bore. The horizontal style is illustrated.

A. Schrader's Sons, Div., Scoville Mfg. Co., Inc., 470 Vanderbilt Ave., Brooklyn 17, N. Y.

Spray Nozzle Atomizes Low Pressure Liquids

This new line of spray nozzles has a unique spiral design that produces a finer atomization yet is practically nonclogging, according to the manufacturer. The New Bete Nozzles shear from a single, high velocity jet a continuous film which readily breaks up into uniformly fine particles at relatively low pressures. No vanes or whirl discs are required as is customary with most conventional nozzles. The company is now producing the new type nozzle in various spray patterns and with flow rates from ¼ to 100 gpm. They can be used for all kinds of spray problems where a fine breakup at low pressures is required.



Bete Fog Nozzle Co., Greenfield, Mass.

By-Pass Pump Delivers Constant Fluid Volume

Called the "Eco Built-In Hydraulically Balanced By-Pass", this pump delivers a constant volume of fluid at constant pressure regardless of variation in line pressure. This is an improvement over the conventional by-pass pump, which merely returns to the suction side of the pump (or to drain outlet) the amount of fluid in excess of the set pressure.

Pressures can be adjusted from 20 to 150 psi on the discharge side. At the varying pressures, volumes of 3/10 to 1½ gpm can be dependably provided. Water, oils, and most other liquids can be handled. The entire operation involves only four small parts. There are no rubber diaphragms to cause trouble. Four sizes are made, with ¼, ⅜, ½, and ¾ in. pipe connections. Pump housings are of forged bronze, other parts are of monel.

Eco Engineering Co., 12 New York Ave., Newark 1, N. J.

CONTINUED ON PAGE 182

the New Arithmetic in Steel

Make each ton of steel go farther. Get four products in place of three from the same amount of steel. Let the high physical properties of N-A-X HIGH-TENSILE take the place of mass in your product design to boost production per ton as much as 33%. This new efficiency in the use of steel is part of industry's constant search for better materials.

With N-A-X HIGH-TENSILE steel you are assured of high resistance to distortion, impact fatigue and corrosion. Yet you are also assured of excellent cold formability and weldability.

Thus you can redesign many steel products with sections 25% thinner—to save weight, save steel. And further savings in fabricating and finishing pay the way to use of this better, more efficient material.

Let us talk over with you the application of N-A-X HIGH-TENSILE to your product. We believe we can show you how to increase production per ton as much as 33%.

N-A-X HIGH-TENSILE STEEL

GOES FARTHER

Builds More Products per Ton

MAKE A TON OF SHEET STEEL GO FARTHER
Specify N-A-X HIGH-TENSILE STEEL

GREAT LAKES STEEL CORPORATION

N-A-X ALLOY DIVISION • ECORSE, DETROIT 29, MICHIGAN • UNIT OF NATIONAL STEEL CORPORATION

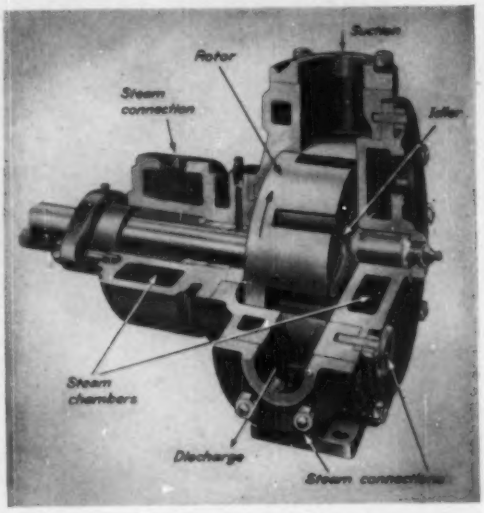
Rotary Pump Maintains Uniform Fluid Temperature

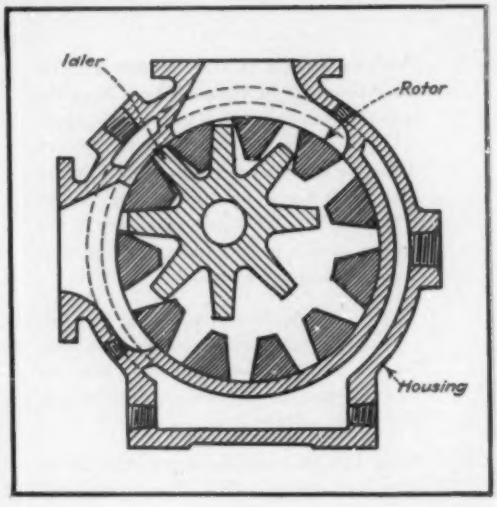
Available in capacities of 90, 200, 300 and 450 gpm, these pumps are designed for handling heavy petroleum, organic oil, chocolate, enamels, printing ink, greases, coal tar, soap solutions, molasses and other heavy, viscous liquids which must be kept warm and in a flowing state for efficient handling. In addition, the working parts of the pump are allowed the extra clearance necessary.

An individual chamber surrounds the casing, head and rotor bearing sleeve. Each chamber is provided with separate openings for connection to steam or cooling lines. The rotor bearing sleeve jacket prevents the liquid being handled from hardening and setting in the packing box.

It is possible to obtain these pumps without one or more of the three heating jackets shown. In addition, the casings can be furnished in either right or left hand construction. The direction of rotation of the rotor can be changed to reverse the direction of flow. These pumps are available in iron, bronze, or steel fitting construction. The overall size of the 450 gpm pump is 17½ wide; 20 7/16 high and 20⅞ long neglecting 23 in. of rotor shaft. These pumps come in four sizes, as noted above, and may be ordered without a separate drive, or with a gear, v-belt, flat belt, or direct drive. When a gear ratio greater than 6 to 1 is required, double reduction units are available. When the viscosity of the liquid at pumping temperature exceeds 750 SSU, a reduction of the speed is advisable.

Viking Pump Co., Eder Falls, Iowa





Gpm	Pump Rpm	Flange Ports	Approx. Shipping Weight Pump Only	Shaft Dia. in.	Unit Includes Drive Capable of Transmitting	
					Hp	at Motor Rpm
90	390	2½	180	1 7/16	5	1800
200	375	3	350	1 11/16	10	1800
300	300	4	530	1 15/16	15	1800
450	260	5	680	2 7/16	25	1200

Precision Switch Has High Rating

This switch, type SXX, is rated for 20 amp at 125 v, ac and for 15 amp at 250 v, ac. It can be adapted for a variety of applications by use of standard "Unimax Adaptaplates". This switch can be actuated by means of a leaf, leaf-roller, hinge, plunger, push-on, push-off and many other devices.

Force and movement specifications are as follows: operating force, 9 to 13 oz; release force, 4 oz min; movement differential, 0.005 in. maximum.

Unimax Switch Div., W. L. Maxson Corp., 460 W. 34th St., New York 1, N. Y.

Instrument Base Damps Vibration

This mount has been designed to protect delicate mechanical, electrical or optical instruments from vibrations as low as 70 cycles per second. It is constructed of non-ferrous materials and can be use for laboratory instruments which must be free of any magnetic influence.

The "Instru-Mount" measures 22 by 12 in. with a height of 3¼ in. and weighs 50 pounds. This mount is supported on four multi-plane shock absorbers and can support instruments of up to 40 pounds in weight.

Eberbach & Son Co., Ann Arbor, Mich.

CONTINUED ON PAGE 184

Winner of Blue Ribbon Award in Power Driving

TYPE "A" ASSEMBLY BIT

COMMON SCREWDRIVER

Engineering and Production Executives vote this award to CLUTCH HEAD Screws on the score of production increases ranging from 15% to 50%... plus the added savings accruing from the elimination of costly skid damage and of burred or chewed-up heads. On the basis of experience resulting from change-over from other types of recessed head screws, here is how these users score CLUTCH HEAD supremacy:

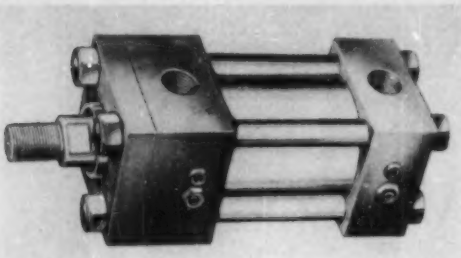
1. High visibility of the clutch recess inspires operator confidence for unhesitating faster driving, while dead-center entry with the Center Pivot Column prevents driver canting. Straight driving is automatic ... hence no burred or chewed-up heads.
2. Absence of "ride-out," due to CLUTCH HEAD'S non-tapered driving engagement, checks out hazard of driver skidding. Freedom from end pressure makes driving effortless, safer and smoother for a stepped up tempo.
3. The Lock-On to check out fumble spots ... screw and bit locking as a unit to permit one-handed reaching and driving from any angle.
4. The unequalled durability of the Type "A" Bit with a record of driving 214,000 screws non-stop ... plus the economy of its repeatable reconditioning in a simple 60-second operation.
5. The importance of CLUTCH HEAD'S basic design for common screwdriver operation ... to simplify adjustments and cure field service "headaches."

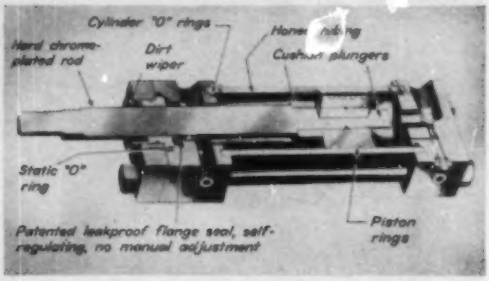
Make your own test of these exclusive CLUTCH HEAD features. Ask us to mail you screw assortment, sample Type "A" Bit and illustrated Brochure.

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 — CHICAGO 8 — NEW YORK 7

Hydraulic Cylinders Meet New Standards





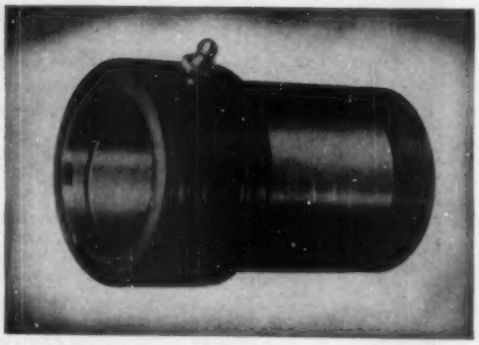
DESIGNED SPECIFICALLY to meet the new "JIC Hydraulic Standards", these high pressure hydraulic cylinders are available in a complete standard line. The line includes bores from 1½ to 12 in. in diameter, and cylinders for 2,000 to 3,500 psi operation. They have solid steel heads, caps, and mountings, and meet all recommendations of the "Standards" specifically related to sealing devices, cylinders, and pistons. Automotive step-cut piston ring assemblies are available and are interchangeable with standard leather piston cup seal assembly.

MAIN CONSTRUCTION FEATURES are pointed out above. "O"-rings provide the required leakproof pressure sealing at cylinder ends; a leather rod seal assembly permits friction-free, leakproof operation of the reciprocating rod; the cylinder bore is honed to a 15 micro-inch polished finish within 0.0005 in. tolerance; and other features are as outlined above. Air bleeds are available to prevent air entrapment. Also, cylinders may have cushioning at one or both ends, with standard mounting dimensions the same as for non-cushioned cylinders.

Miller Motor Co., 4027 N. Kedzie Ave., Chicago 18, Ill.

Guide Bushings Have Bronze-Plated Friction Surfaces

To minimize the problem of scoring and seizing of steel guide pins and bushings for stamping dies the inside friction surfaces of these new bushings have been bronze plated. In addition, a grease fitting leading to oil grooves provides adequate lubrication of the sliding surfaces. These features have been tested under severe conditions and proven to be trouble-free. This hardened steel bushing, with a 0.001 to 0.002 plating, eliminates the out-of-round and bell-mouth wear which is characteristic of soft, non-ferrous bushings. These bushings are manufactured in standard sizes for die guide pins and can be also produced for other guide bushing applications. Bushings are normally made for the three standard types of guide pins; the straight, shoulder, and removable pin type.



Lamina Die and Tools, Inc., 14925 W. Eleven Mile Rd., Berkley, Mich.

Frequency Sensitive Relay Has Small Frequency Differential

Featuring a frequency differential of ¼ of one percent, the Series 900 frequency sensitive relay is made for the protection of instruments from the effects of under or over frequency.

The relay is designed to open a 400 cycle supply circuit when the frequency falls below a predetermined safe point, thus insuring positive protection for valuable equipment, against excessive currents due to the lowering of impedance when the frequency drops. It is hermetically sealed, having 5 amp, double pole, double throw contacts. The operating current is derived from the main power source. It may be used on voltages from 75 to 150 at frequencies from 350 to 1000 cps without injury to the relay circuit. The relay can be furnished to open or close at frequencies from 350 to 1000 cps with a differential from 2 to 20 cps.

Varo Mfg. Co., Inc., Box 638, Garland, Tex.

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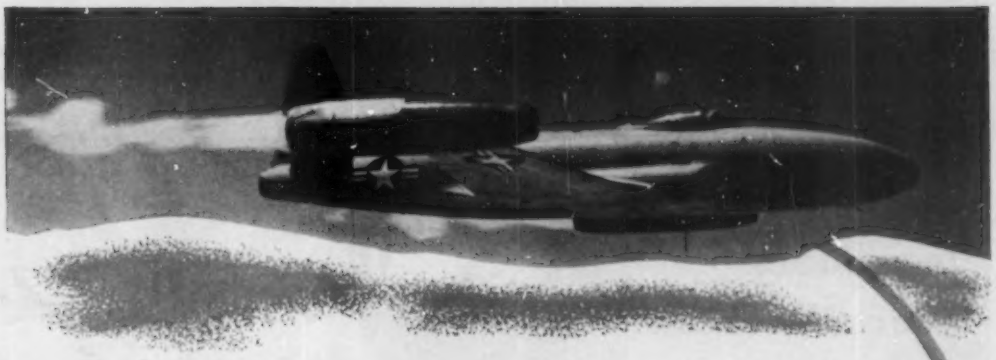


FROM FIERY RAM JET ENGINES...

TO FROSTY ICE CREAM FREEZERS

MILES HIGH in the sky, where temperatures may reach 65° below zero, ram jet engines snort their fiery breath through nostrils of Republic ENDURO Stainless Steel. It takes a mighty good metal to withstand the destructive effect of extreme heat on the inside, freezing cold on the outside.

Or . . . an entirely different type of application—an ice cream freezer. It has a problem of low temperature, but an even greater one of resistance to coolant solutions PLUS complete sanitation and ease of cleaning. The material used? Why ENDURO, of course!

There seemingly is no end to the long list of uses for stainless steel—because no other material has so many advantages.

Its strength and toughness—its resistance to rust, corrosion and heat—give it stamina to stand up in service, to cut maintenance and replacement costs. Its sanitary surface, freedom from contamination and ease of cleaning safeguard product quality—help cut processing costs.

The eye appeal of its silvery lustre becomes "buy appeal" in products made of or trimmed with it. It adds that final decorative touch to automobiles and skyscrapers alike. Yes, it's the "Thrifty Metal of 10,000 Uses."

No matter what you make, there must be some place in your product or plant where ENDURO will pay its way. Republic engineers and metallurgists are ready to tell you "how."

ENDURO is solid stainless steel all the way through. There's nothing to chip, peel or wear off. It stays new-looking—lasts indefinitely.

Distributor stocks and competent fabricators are located in principal cities. Your local Republic representative is prepared to answer your questions.

Enduro® STAINLESS STEEL

REPUBLIC STEEL

RUST-RESISTANT • CORROSION-RESISTANT • HEAT-RESISTANT • ATTRACTIVE • SANITARY • EASY TO CLEAN
EASY TO FABRICATE • STRONG • LONG-LASTING • LOW IN END COST • What more can be desired in a material?

REPUBLIC STEEL CORPORATION • *Alloy Steel Division, Massillon, Ohio* • **GENERAL OFFICES, CLEVELAND 1, OHIO**
Export Department: Chrysler Building, New York 17, N. Y.

Panel Instruments Withstand Shock

Panel instrument can be tumbled, vibrated severely for hours, or struck repeatedly with 2,000 foot pound blows without loss of accuracy.

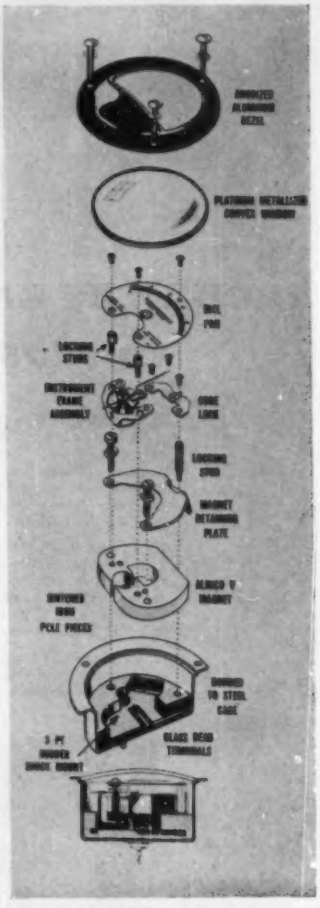
REDESIGNED PANEL instruments are interchangeable physically and electrically with existing JAN types and yet will withstand nine direct blows up to 2,000 foot-pounds. A completely redesigned internal structure gives needed strength.

Called the "Ruggedized" line, these panel instruments are made in standard 1½, 2½, 3½, and 4½ in. sizes and in the MR 26 and MR 36 series. They are interchangeable physically and electrically with existing JAN types. Good performance under shock conditions has been attained with a completely new internally shock mounted D'Arsonval type of movement which has had its mass sharply reduced. The instruments are also designed to provide improved electrical accuracy and performance. The shock mount attenuates high amplitude, low frequency shock forces and a revised frame structure secures the core against shock failure.

Stainless steel screws replace the usual brass screws and new magnet holding brackets distribute shock forces over greater area to prevent failure. Silver coated beryllium copper springs of the shortest possible length and the highest natural resonance are used as hairsprings. These are formed with the smallest outside diameter possible and given sufficiently extended normalizing heat treatment to assure removal of the cold worked stresses introduced in assembly operations. Tantallum tungsten pivots and hard borosilicate glass jewels are used in the movement to give further protection from shock and vibration.

Instrument pointers are made of 52SH aluminum alloy tubing, and not only withstand a greater shock load, but also allow greater electrical overload without pointer damage. A new panel mount completes this redesigned line of panel instruments. This panel mount includes a new shock-mounting ring which distributes shock forces evenly around the whole periphery, rather than at the bolt heads. This ring also facilitates assembly of the meter to a panel in close quarters.

Marion Electrical Instrument Co., Manchester, N. H.



EXPLODED VIEW shows all component parts. Each part has been redesigned for increased strength and accuracy.

Rotary Swivel Joint Requires Low Torque

Made for use with air, oil, gas, steam, water, and other fluids, this rotary swivel joint eliminates wedge action of the ball against the gasket, to cut down considerably on turning torque. The ball is held in place by a Belleville spring. A small amount of side flexibility reduces wear or breakage from side strain.

Applications include use with hydraulic machinery, cylinders, die heads, rolls, and platens, under vacuum or pressure. The joint will not leak under alternating steam and cold water. It is presently available in 90 deg angle and straight designs in ⅜ to 1 in. pipe sizes. Rotation is full 360 deg, with enough side flexibility to correct for piping misalignment.

There is no restricted internal diameter as is normally found in flexible hose. Standard joints are made for steam pressures up to 300 psi, and extra-heavy joints can be obtained for use with higher temperatures and pressures. Continuous rotations up to 30 rpm are possible with standard joints.

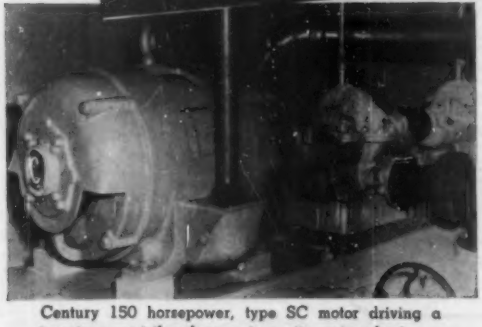
Barco Mfg. Co., Dept. 113, 1801 West Winnemac, Chicago 40, Ill.

CONTINUED ON PAGE 188

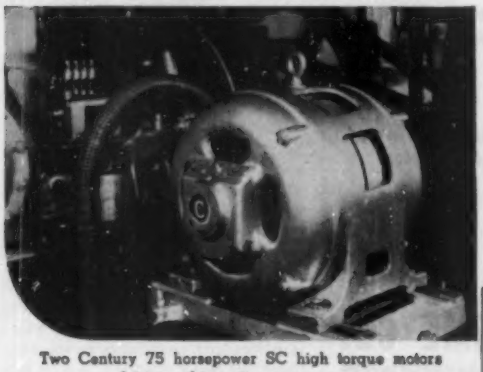
Century 40 horsepower, type SC motor driving an induced draft fan for a stack.

From Century's Line of Electric Motors You Can Select

1. **Right Kind**—*to match your current supply*
2. **Right Type**—*to meet your load characteristics*
3. **Right Protection**—*against atmospheric hazards*
4. **Right Size**—*from 1/6 to 400 horsepower*



Century 150 horsepower, type SC motor driving a two-stage centrifugal pump in a city water plant.



Two Century 75 horsepower SC high torque motors driving refrigeration compressors.

The wide range of kinds, types and sizes of Century motors makes it possible to select a standard motor to meet the requirements of all popular applications.

They are available for both AC and DC current—high, normal and low torque characteristics. Types are also available for applications requiring varying speeds and reversing direction of rotation.

To protect against atmospheric hazards, Century motors are enclosed in open rated drip proof, splashproof, totally enclosed fan cooled and explosion proof frames. Many types are available with vertical and flange mountings as well as standard horizontal bases.

Specify Century motors for all your electric power requirements.

Popular sizes and standard ratings are generally available from factory and branch office stocks.

Century C MOTORS

CENTURY ELECTRIC CO.
1806 Pine Street, Saint Louis 3, Missouri
Offices and Stock Points in Principal Cities

Elapsed time intervals can be measured down to 1/1000th second with a

STANDARD PRECISION TIMER

The world's most accurate (and rugged) time measuring instrument. Available in 8 models as shown below:

MODEL	READS	TOTALIZES	ACCURACY
S-100	1/5 sec.	6000 sec.	± .1 sec.
S-60	1/5 sec.	60 min.	± .1 sec.
SM-60	1/100 min.	60 min.	± .002 min.
S-10	1/10 sec.	1000 sec.	± .02 sec.
S-6	1/1000 min.	10 min.	± .0002 min.
S-1	1/100 sec.	60 sec.	± .01 sec.
MST	1/1000 sec.	.360 sec.	± .001 sec.
MST-500	1/1000 sec.	30 sec.	± .002 sec.

Manually and Electrically Operated Portable Cases or Panel Mounting optional changes to conform to customers' requirements.

Special Timing Problem. **Our engineers are ready to consult with you, and design timers to meet special timing problems.**

OTHER PRODUCTS

Standard Chrono-Tachometers, Custom-built Laboratory Test and Distribution Panels, School Time Program Systems, Hospital Doctor Paging and Nurse Call Systems.

WRITE FOR BULLETIN NO. 153

STANDARD

THE STANDARD ELECTRIC TIME CO.

95 LOGAN STREET **SPRINGFIELD, MASSACHUSETTS**

Sealed Photoelectric Cell

New hermetically-sealed selenium photoelectric cell having an average current sensitivity of 600 microamperes at an illumination of 100 foot candles with a 100 ohm external circuit resistance has been developed. The assembly features an extruded brass case using a glass to metal sealing alloy to secure perfect sealing. This selenium photoelectric cell is of the self-generating type and does not require any external source of power. This unit can be used for automatic counting, burglar alarms, and testing lights. The hermetically-sealed cell is especially applicable for outdoor uses such as turning on street lamps and

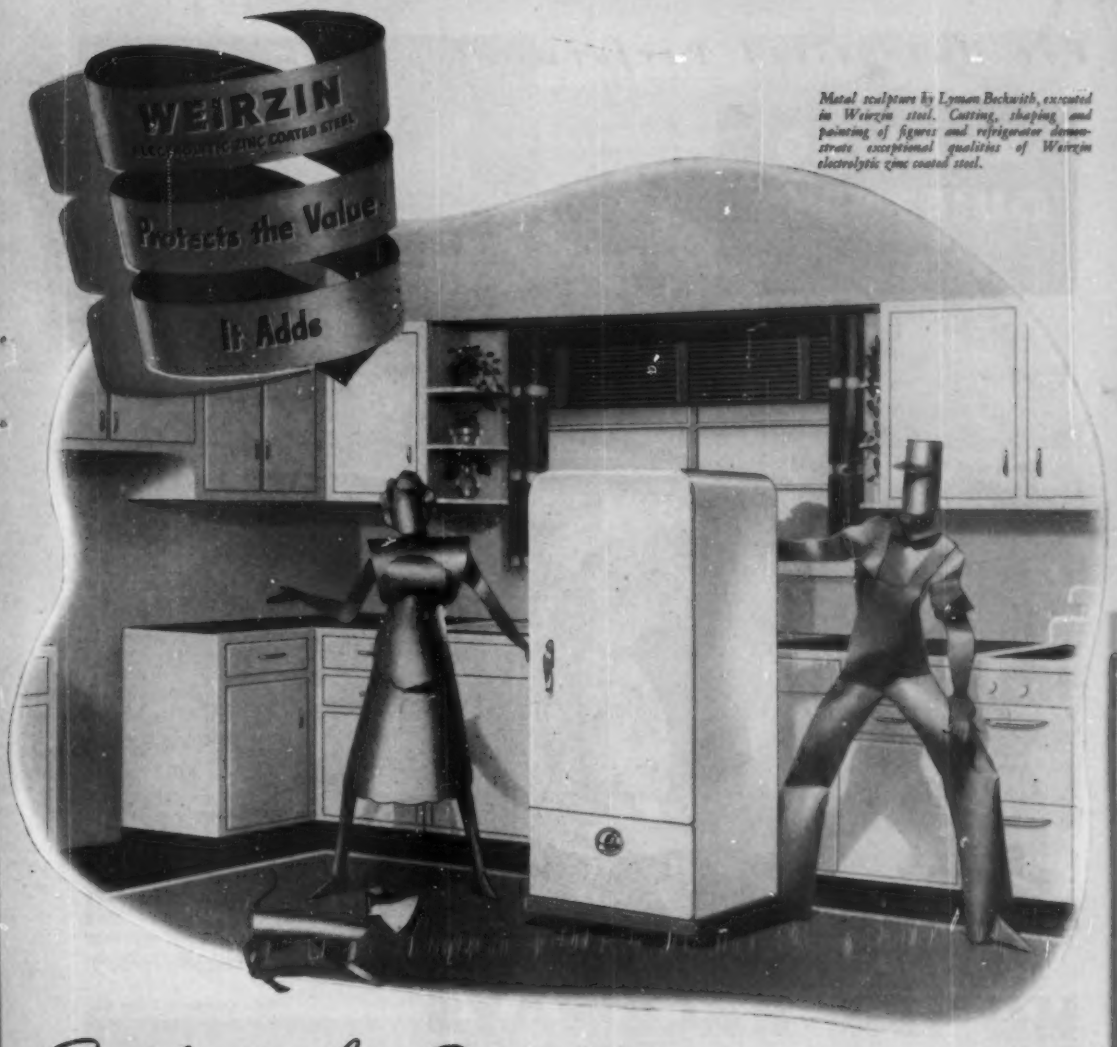
advertising signs. It is also used on shipboard smoke detectors and other marine uses where excessive moisture and salt spray may affect the operation of the cell.

The case is square and measures 2 inches square by $\frac{7}{16}$ inches thick. The active cell area is approximately 2.25 square inches and the positive contact is made by a center lug and the negative terminal lug is located $\frac{3}{4}$ inches away from the positive one. Two insulated mounting screws are located $\frac{1}{2}$ inches on either side of the positive contacts.

International Rectifier Corp., 3809 S. Victoria Ave., Los Angeles, Calif.

Tamper-Proof Stroke Counter

Silver King mechanical counters are heavy duty stroke counters especially suited for industrial applications, such as punch presses, drill presses, milling machines and other production equipment. The modern design incorporates steel base and cover with chromium finish, light-weight plastic number wheels for reduced inertia and unbreakable windows of reinforced plastic. The new development, which is particularly advantageous for automatic piecework counting, is a built-in



Metal sculpture by Lyman Beckwith, executed in Weirzin steel. Cutting, shaping and painting of figures and refrigerator demonstrate exceptional qualities of Weirzin electrolytic zinc coated steel.

Special recipe for a Dream Kitchen—

The home-owner whose kitchen appliances are made of Weirzin is fortunate indeed . . . for products made of this superior electrolytic zinc coated steel are extra good to start with and *stay* extra good.

Why? Well, for one thing, Weirzin's superior strength and workability make it easy and economical for appliance manufacturers to turn out flawless products. Also, Weirzin is highly corrosion-resistant in itself; in fact, it does not require a protective finish to preserve it.

And when used in appliances that are to be beautified in gleaming white or color, Weirzin has the happy faculty of taking enamel, lacquer, or paint, and holding on to it for keeps. So, the beauty of your appliance is bound to last—because the finish *clings* to Weirzin.

Leading manufacturers of appliances, metal wall tile, storm sash, kitchen cabinets, and other steel products, are using Weirzin because it facilitates production and creates customer satisfaction. Weirzin protects the value it adds to make good products better.

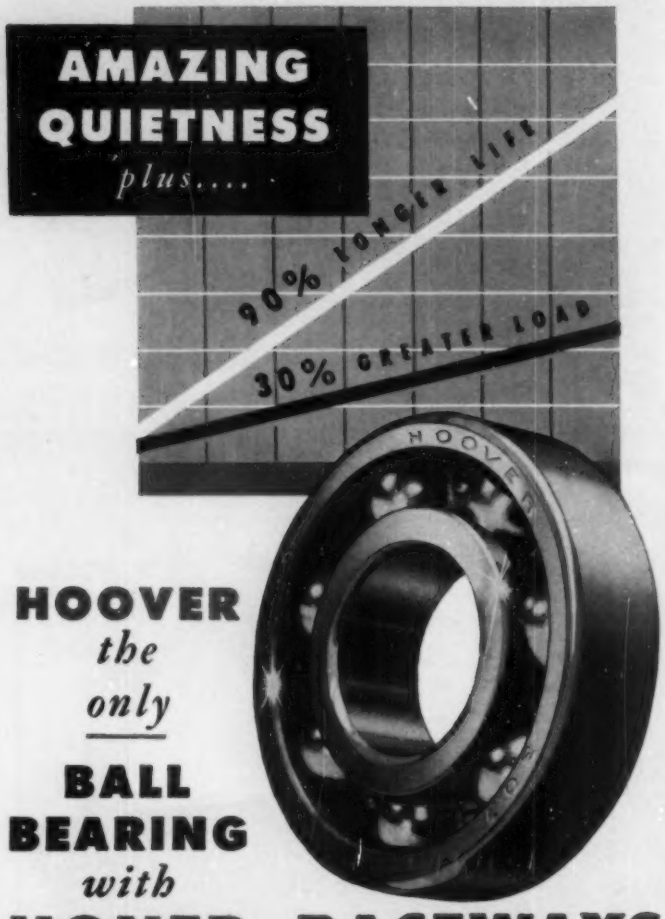
WEIRTON STEEL CO.

WEIRTON, W. VA., Sales Offices in Principal Cities
Division of NATIONAL STEEL CORPORATION, Executive Offices, Pittsburgh, Pennsylvania

WEIRTON STEEL COMPANY

Weirzin Electrolytic Zinc Coated Sheets and Strip • Weirite Tin Plate and Tin Mill Products • Hot-Rolled and Cold-Rolled Sheets and Strip • High-Carbon Strip Cold-Rolled Spring Steel

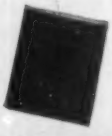
For Unexcelled Performance



HOOVER *the only* **BALL BEARING** *with* **HONED RACEWAYS**

Here are three pertinent reasons why you should consider Hoover Ball Bearings — with honed raceways. First, these bearings achieve unbelievable quietness. Second, they increase bearing life 90 per cent. Third they have a 30 per cent greater load capacity. When you specify Hoover Ball Bearings you secure these PLUS features without extra cost.

The Hoover Engineering Manual gives all the facts. Write for your copy.



THE ARISTOCRAT OF BEARINGS

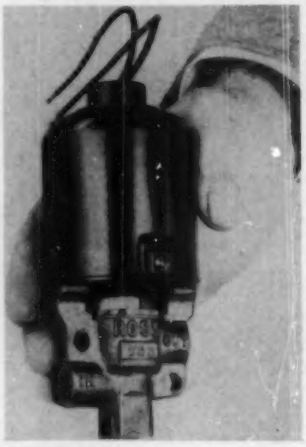
HOOVER BALL and BEARING CO.
Ann Arbor, Michigan

device that prevents reverse operation of the reset mechanism. Any tampering with the reset knob is easily detected. In addition to the tamper-proof knob-reset model the counters are available in key-reset and non-reset models.

Production Instrument Co., 702-10 W. Jackson Blvd., Chicago 6, Ill.

Small Solenoid Valve

This new valve has ¼ in. connections and is straightway or 3-way, with in-line, side, bottom or panel mountings. It is direct operated, uses a standard



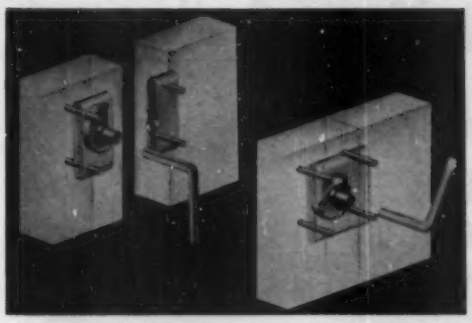
solenoid, and is available in both normally open and normally closed models. The straightway units are suitable for the control of liquids since corrosion-resistant materials are used throughout. All parts are easily replaceable.

Ross Operating Valve Co., 120 E. Golden Gate Ave., Detroit 3, Mich.

Corrosion-Resistant Globe Valve

A newly designed "Karbate" Brand Impervious Graphite globe valve is designed for shut-off and throttling service with corrosive fluids free from abrasive solids. Except for the Teflon packing all valve parts in contact with the fluid are "Karbate" Impervious Graphite, thus preventing corrosion and contamination and cutting replacement and maintenance expenses.

The outstanding features of the new globe valve are its resistance to practically all corrosive chemicals, including hydrochloric acid, dilute sulphuric and hydrofluoric acids and chlorinated organic compounds, and its resistance to



Operation of Roto-Lock is simple. The tapered, serrated cam engages the lip and pulls the panels together. Any hand tool—hex wrench, screwdriver, etc.—can be used. Roto-Lock recesses completely into the panel, leaving no unsightly or damageable parts exposed.

Interior and exterior of Arctic shelter fabricated from honeycomb panels and fastened with Roto-Locks. Roto-Lock fastens even in seriously misaligned conditions and locks in any semiopen position. It carries high-tension loads and heavy-shear loads, providing a complete structural connection.

PHOTOS COURTESY BAKELITE CORPORATION

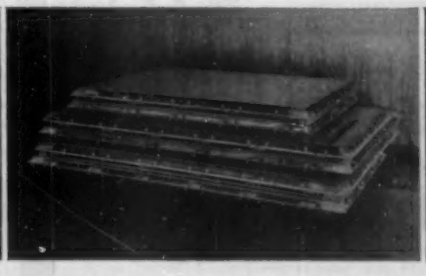
Roto-Lock Fasteners Have Universal Application in Demountable Panel Construction

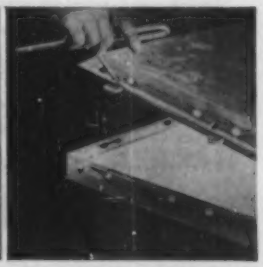
Faced with the problem of fabricating a demountable Arctic shelter from their new paneling, U. S. Plywood Corporation needed a fastener which would lock the panels quickly and easily, and make a weathertight seal against Arctic winds.

The Simmons Fastener Corporation found the answer to this and many other panel-fastening problems in the new Roto-Lock fastener. The Roto-Lock, simple in design and easy to operate, fastens any panel, butt-joint or right angle, with sufficient pressure to create an air- and watertight seal. It has no springs or other delicate mechanical parts to be affected by temperature or field service.

Air-freight and cold-storage shipping containers, walk-in coolers, furniture, scaffolding and many other items have been made with honeycomb panels—and fastened with Roto-Lock. Panels of any material can be fastened with equal ease—plywood, Kaylo, marinite, Masonite, wood or metal.

Roto-Lock literature, showing numerous applications, as well as complete design specifications, is offered as an aid to manufacturers and designers in solving *their* panel-fastening problems. Write for it today.





Lightweight knock-down shipping box greatly reduces shipping charges. Roto-Lock (photograph at right) exerts enough pressure on the gasketing between panels to provide an air- and watertight seal. It can be mounted with no through parts—eliminating transmittal of heat or cold from exterior to interior surfaces.

Simmons Fastener Corporation
1751 NORTH BROADWAY, ALBANY 1, N. Y.

QUICK-LOCK...
SPRING-LOCK...
ROTO-LOCK...

Discover how wonderfully small trifling expenses mount up to large sums.

—*Ben Franklin's Almanac, 1757*

A single per cent saved here and another per cent saved there strengthens thy working capital for the coming year.

—*Acme Steel's Notebook, 1950*

Look, Mr. Management, how long has it been since you walked through your shipping room and checked up on your packaging operations?

How long since you sharpened your eye and your pencil on ways to save in shipping and materials handling?

Helping you save money, time, materials, labor is where Acme Steel comes in. Nine out of ten companies start cutting costs when they reach for the telephone and call in one of our sales engineers and get the benefit of what we have learned to do with Acme flat steel strapping, Acme stitching machines and wire, and other Acme Steel products.

We show you here two specific examples of savings by our customers. If you want more evidence, we have hundreds of actual case studies to show you. In fact, more than 45,000 Acme customers are getting the benefits of Acme Methods now. Call the Acme Steel service office nearest you. (There are 45 of these offices in the principal cities of the U.S. and Canada.) Or send the coupon below for more details on your special problems.

OLD WAY: 17½¢ per assembly
ACME STEEL WAY: 3½¢ per assembly
SAVINGS: 14¢ per assembly
BONUS: a stronger fastening!

Holland Furnace Company replaces riveting by wire stitching asbestos cloth to a steel frame with Acme-Morrison metal stitcher.

ACME STEEL

Fastening operation costs cut 68% with ACME-MORRISON metal stitchers!

Using metal stitches instead of screws, a manufacturer of spray guns cut 68% from the cost of fastening a wood plug to a metal tube.

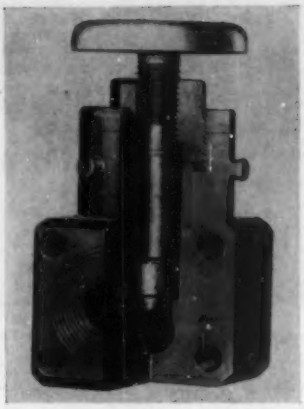
Under the American business system of open competition, Acme Steel has enjoyed sound, steady growth. Since 1901, Acme Steel has made 283 consecutive dividend payments to its stockholders.

ATTACH THIS COUPON TO YOUR BUSINESS LETTERHEAD

ACME STEEL COMPANY, Dept. PE-40, 2840 Archer Avenue, Chicago 8, Illinois
We manufacture _____. Please send me booklets on Acme Methods checked.

- ☐ Please have sales engineer call.
- ☐ **Product Assembly**—"Acme-Morrison Metal Stitchers"—for savings in fastening metal-to-metal or metal-to-other materials.
- ☐ **Packaging, Shipping, Materials Handling**—"Savings in Shipping" tells how to save money and safeguard customer good will with Acme Steelstrap.
- ☐ **Shipping (Carload and L.C.L.)**—"Acme Unit-Load"—The story of reduced damage claims and better handling for shippers.
- ☐ **Bag and Box Assembly**—"Profit by Stitching" demonstrates cost-cutting Acme Silverstitchers and Acme-Champion Stitchers.
- ☐ **Book Assembly**—"Acme-Morrison Book Stitchers" for savings in the graphic arts field.

NAME _____ POSITION _____
COMPANY _____
STREET _____
CITY _____ ZONE _____ STATE _____

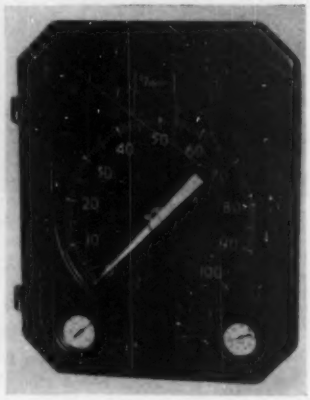


thermal shock. Because of the excellent thermal conductivity of impervious graphite the valve may be readily heated from a steam coil of copper tubing wrapped around it, when heating is required for handling highly viscous or saturated solutions. Valves are available in 1 and 2 in. sizes. The tapered disk valve seat assures accurate and close control of fluid flow, and it is self-reseating. The valve is light and small, has short face to face dimensions and is self-lubricating.

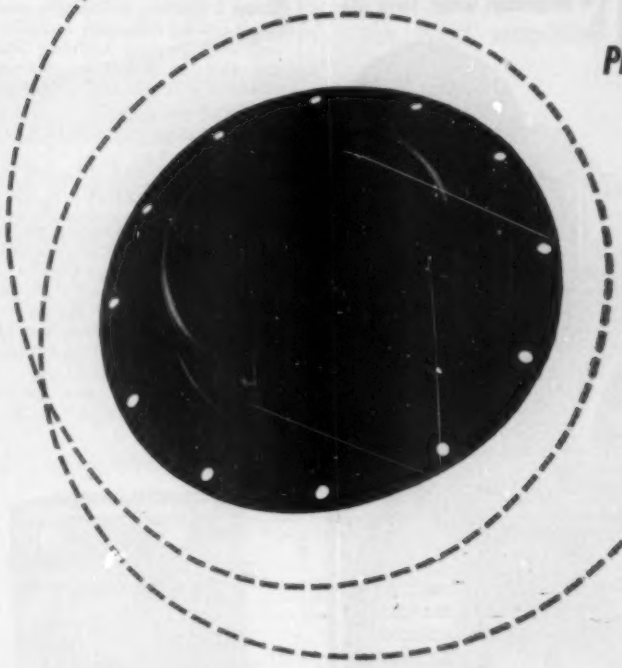
National Carbon Div., Union Carbide and Carbon Corp., 30 E. 42 St., N. Y. 17, N. Y.

Dial Indicators

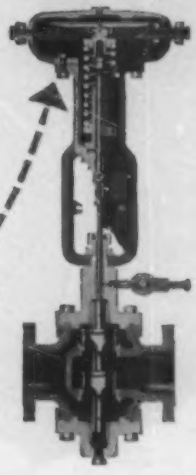
This new "Concentric" or "Full-Circle Dial Indicator" is for transmitting, receiving and controlling instruments. It has a unique dial construction which makes the instrument mechanism easily accessible for inspection or adjustment by simple rotation of the dial. A large pointer with 270 deg sweep, together with white numerals on a black background, stand



Keeping the Pulse of Automatic Control . . . with a LINEAR MOULDED DIAPHRAGM



A Special LINEAR Precision Moulded Diaphragm is the heart of this Honeywell Series 700 Control Valve



This high-lift, proportional type valve is precision-engineered from top to bottom. And *just as important* as the flow characteristics of its inner valve are *the sensitivity and dependability of its air-operated diaphragm.*

According to Honeywell engineers, this LINEAR Diaphragm . . . precision moulded to their specifications . . . affords these definite operating advantages:

. . . lasts for millions of cycles.

. . . gives uniform performance under varying temperature conditions.

. . . remains sensitive throughout its service life.

. . . withstands accidental overload pressures.

. . . permits smooth action for minute movements.

. . . provides a pressure-tight seal without strain on the cast flange.

Your diaphragm problems can be solved, by LINEAR, with the same special engineering attention. Whether you need heavy-duty, fabric-reinforced diaphragms or the super-sensitive homogeneous type . . . Your individual specifications will be our guide. Write, wire or call LINEAR today!

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK STREET, PHILADELPHIA 35, PA.

ORANGE
Cage Type
NEEDLE BEARINGS

- Minimum space
- High precision
- Simplified, compact design
- Minimum wear, long life

meet critical needs of spindle shank mountings in

POTTER & JOHNSTON
Multiple Spindle Drill Heads

The P & J self-driven Multiple Spindle Drill Head—operating directly from the turret of P & J Automatics—drills, countersinks or reams any number of holes to precision specifications for size, location and alignment, all in one holding. Action, including feed, is fully automatic.

● Wherever you require bearings for spindles—high speed applications—or vertical operation, Orange Cage Type Needle Bearings are the ideal bearings. All rollers are held in permanent alignment by a free-floating, land-riding cage made of anti-friction, non-ferrous metal, which prevents skewing while running. Pockets are coined to contour of rollers. Internal clearances can be accurately controlled to meet exacting requirements. These features also permit successful installation in overhung mountings and minimize the effects of mis-aligned mountings.

All rollers and races "Pentrate" finished for corrosion resistance and reduced friction. Extremely smooth, quiet running, with longer life expectancy. Write for Engineering Data or consult our field representative.

ORANGE

ORANGE ROLLER BEARING CO., INC.
951 Main Street, Orange, N. J.

out effectively so that they can be read from 50 to 100 feet. The instrument may be used with only low pressure unit or mercury manometer actuation for differential or absolute pressure applications. It is available as a simple indicator, indicating receiver, indicating controller, indicating transmitter, indicating transmitter controller or indicating receiving controller. Standard ranges are 0 to 10 on square root scale and 0 to 100 and 0 to 200 on uniform scales.

Taylor Instrument Co., Rochester 1, N. Y.

DC Power Source

The "Varicell" provides a stabilized and regulated source of variable d-c voltage from a-c power lines. It operates from a 95 to 135 v, 60 cycle, single phase ac line; delivers a dc output that is variable from 0 to 30 v. The allowable output current available at any voltage setting is 15 amps.

The d-c output voltage of the Varicell is stabilized. Regardless of a-c

line voltage fluctuations, the set value of d-c output voltage does not change. The unit is also regulated, which means that the d-c output voltage remains constant although the load may vary. Stabilization and regulation are given as 0.25 percent for an output setting between 6 and 30 v. RMS ripple voltage does not exceed ±0.1 volts.

The Superior Electric Co., Bristol, Conn.

High Temperature Switch

Production of a new High Temperature Control Switch has been announced. Designed for use in jet engines, gas turbins, rocket motors and after burner controls, the new switch operates from 0 to 2,000 F—normally open. This switch grounds out at specific temperatures. It is outstanding for its ability to maintain temperature calibration for 100 hours

WAGNER MOTORS
...The choice of leaders in industry

Here's what you get in the WAGNER *Type RA* MOTOR...

the most simplified design to provide—

repulsion start

HIGH STARTING TORQUE . . . for quick, easy starting and smooth acceleration.

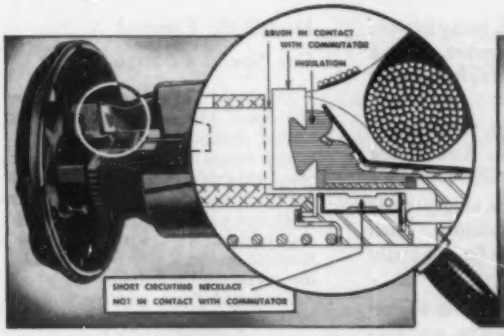
LOW STARTING CURRENT . . . to minimize light flicker when motor starts.

induction run

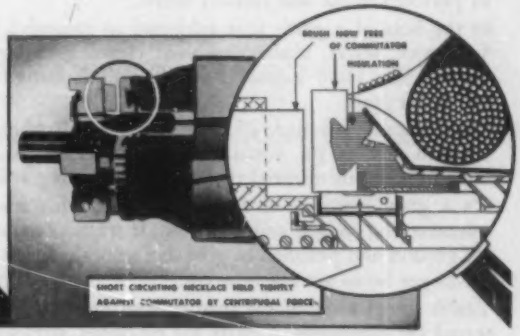
HIGH OPERATING SPEED . . . constant at all operating loads, even under overload.

FLAT EFFICIENCY CURVE . . . over a wide operating range.

Pioneered by Wagner more than half a century ago, the repulsion-start induction single phase motor is truly industry's "general purpose" motor because it combines the best features of two types of motors: the repulsion motor during the starting period and the induction motor while running at rated operating speeds. Today, the Wagner Type RA offers the most simplified, trouble-free design available, and is still the standard by which all other single phase motors are judged. In the Wagner Type RA Motor you get low upkeep cost, minimum servicing, freedom from vibration and noise, and years of reliable service. Shown below are the basic principles of operation of this motor. Bulletin MU-185 gives complete details. Write for a copy.



Starting period—Short-circuiting necklace is out in contact with commutator bars. A governor spring holds barrel in starting position. Brush assembly completes selected circuits enabling motor to start as a repulsion motor.


BRUSH NOW FEEDS OF COMMUTATOR
INSULATION
SHORT CIRCUITING NECKLACE HELD TIGHTLY AGAINST COMMUTATOR BY CENTRIFUGAL FORCE

Running period—Governor weights (actuating pushrods) have forced spring barrel forward until short-circuiting necklace connects commutator bars to short-circuiting ring, forming a "squirrel cage" to permit operation as an induction motor.

Wagner Electric Corporation
EST. WE 1891

WAGNER ELECTRIC CORPORATION
6406 Plymouth Ave., St. Louis 14, Mo., U.S.A.

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS — AIR AND HYDRAULIC

BRANCHES IN 29 PRINCIPAL CITIES

ITS LIFETIME OF
HARD KNOCKS
puts a materials testing laboratory right at your fingertips.

A bowling ball is made to specifications that are *tough!* Tougher than most machine parts.

It takes hard knocks with a bounce, and at the same time retains its perfect balance and smooth finish.

In the heat of a game it is subjected to corrosive perspiration, floor wax, water, chalk, and even cleaning detergents. Yet a genuine Ace Hard Rubber Bowling Ball remains faithful to its owner for years.

That's because it's made of tough Ace Hard Rubber, with tensile strength of 9,000 psi, flexural strength of 11,500 psi. And it's the same impervious material that's used for piping acids.

It's a good example of fabricating, too, with amazingly close tolerances on weight and diameter. It starts as a molding. Then it's ground and polished to give that smooth, satiny feel. Finally the finger holes are machine cut.

Yes, it shows some of the reasons why Ace Hard Rubber is preferred for thousands of parts for machines, appliances, automobiles, furniture, etc. Chances are it's best for some of *your* parts, too. Why not give it a whirl?

Send for free 60-page Ace Handbook —a gold mine of helpful data

ACE AMERICAN HARD RUBBER COMPANY
HARD RUBBER and PLASTICS
11 MERCER STREET • NEW YORK 13, N. Y.

at 1,500 F with an accuracy of 10 deg. F. Flange or screw type mountings are optional. Probe 3 inches long; weight 5½ ounces.

Control Products, Inc., 306 Sussex St., Harrison, N. J.

Vinyl Covered Flexible Metal Conduit

This vinyl covered conduit may be used for electrical shielding purposes in many applications and is particularly suited for use on machine tools because of its resistance to moisture, coolants, greases and oils. The tough, abrasion-resistant cover is applied over a highly flexible galvanized steel convoluted steel tubing. This durable steel core and tough vinyl cover provides a conduit to withstand abuse of installation and the wear of long usage. This conduit is extremely flexible. It will not bind or restrict movement when used between moving parts on machine tools. Liquid-tight steel fittings are usable with both standard and water-tight conduit boxes. They are attachable and re-attachable by the user or can be permanently attached by the manufacturer. Conduit is manufactured in sizes from ⅜ in. to 2 in. inside dia, and can be furnished in mill lengths or cut lengths.

Chicago Metal Hose Corp., 1304 S. Third Ave., Maywood, Ill.

Hydraulic Control For Speed Changer

Developed for use with the Reeves Vari-Speed Motodrive, this hydraulic control device is a sensitive and accurrate means of obtaining automatic speed changing. The control consists of a self-contained hydraulic power plant, and a simple rotary valve, piston and cylinder in a streamlined case, mounted on the Motodrive in place of the customary handwheel.

Connected from any conveniently located speed actuating source to the rotary valve, the control lever directs the flow of oil into the cylinder, which in turn regulates the position of the piston. Movement of the piston changes the effective diameter of the driving pulley and, therefore, the output speed of the motodrive. If an increase in output speed is needed, the oil forces the piston and sliding disk, toward the fixed disk on the motor shaft, making the belt climb to a larger diameter thus increasing the output speed. Reverse action of the piston reduces speed in the same manner.

Reeves Pulley Co., Columbus, Ind.

Send for your copy of this

BRAND NEW CATALOG

today!

64 pages of technical information and pertinent illustrations . . . describing the entire Honeywell line of Industrial Control Devices

THE kind of information you want, right at your finger tips . . . on pneumatic and electric non-indicating controls for temperature, pressure, liquid level and humidity.

Included are these six important additions to the Honeywell line: Electronic Temperature Controllers . . . Magnetic Starters and Contactors . . . Self-Contained Temperature Controllers . . . Automatic Reset Relays . . . Engine Temperature Thermostats . . . Piston Air Motors.

This Brand New Catalog #8303 is complete and factual, contains detailed specifications for each and every product. It belongs in your files . . . for ready reference . . . send for your copy, today!

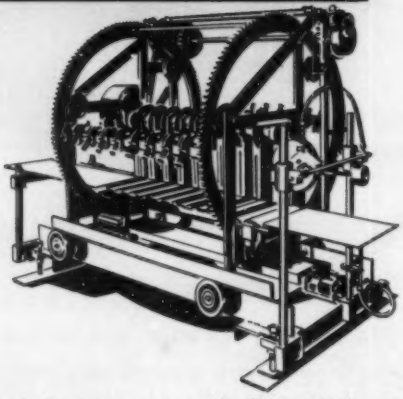
More and more Honeywell Control Devices are simplifying more and more machines and processes in more and more industries.

COMMERCIAL · RESIDENTIAL · INDUSTRIAL
WORLD'S LARGEST ORGANIZATION FOR ADVANCED INSTRUMENTATION AND CONTROL

MINNEAPOLIS-HONEYWELL REGULATOR CO.
INDUSTRIAL DIVISION
4459 Wayne Ave., Philadelphia 44, Pa.
Offices in 77 principal cities of the United States, Canada and throughout the world

Minneapolis Honeywell — *Advanced Instrumentation* FOR BETTER PROCESSING — BROWN INSTRUMENTS

Clay-cutting Brick Machine equipped with Fawick 6CB200 Clutch and 6CB200 Brake.



Intricate machines of all types are constantly proving the advantages of Fawick Airflex Clutch and Brake units in their operation.

When clutch requirements for any machine call for (1) smooth, shock-free starts and stops; (2) quick response; (3) complete and sensitive control; (4) long maintenance-free service—specify FAWICK.

Fawick design and operating features provide clutch or brake action by 360° "constant-velocity" contact on the full width of the friction surface. Torque is transmitted through the flexible rubber tube, cushioning peak shock loads and dampening shaft vibrations.

Add to these the features of complete torque control and remote operating control and you have all components for top-efficiency clutch or brake action—Fawick makes good machines perform better.

For specific information on all advantages of Fawick Clutch and Brake units, write to the Main Office, Cleveland, Ohio, for Bulletin 300.

All desirable clutch characteristics are built into Fawick Airflex units

FAWICK Airflex CO., INC.
9919 CLINTON ROAD CLEVELAND 11, OHIO

FAWICK CLUTCHES = + + + = PEAK EFFICIENCY

MEETINGS

April 10-12

AMERICAN SOCIETY OF LUBRICATION ENGINEERS—Annual Meeting, Hotel Statler, Detroit, Mich.

April 10-14

AMERICAN SOCIETY OF TOOL ENGINEERS—Industrial Exposition on Cost Cutting, Convention Hall, Philadelphia, Pa.

April 11-12

AMERICAN ZINC INSTITUTE—32nd Annual Meeting, Hotel Statler, St. Louis, Missouri.

April 12-13

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Aviation and Gas Turbine Division, Hotel Statler, Washington, D. C.

April 12-14

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Spring Meeting, Hotel Statler, Washington, D. C.

April 17-19

SOCIETY OF AUTOMOTIVE ENGINEERS—Aeronautic Meeting and Display, Hotel Statler, New York.

April 24-26

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Process Industries Division Conference, Hotel William Penn, Pittsburgh, Pa.

April 24-27

AMERICAN MANAGEMENT ASSOCIATION—19th National Packaging Exposition, Navy Pier, Chicago, Ill.

April 25-26

METAL POWDER ASSOCIATION—Sixth Annual Metal Powder Show, Book-Cadillac Hotel, Detroit, Mich.

May 5-6

AMERICAN PHYSICAL SOCIETY—National Meeting and Midwestern Conference on Fluid Dynamics, University of Illinois, Urbana, Ill.

June 4-9

SOCIETY OF AUTOMOTIVE ENGINEERS—Summer Meeting, French Lick, Ind.

June 11-15

AMERICAN ELECTROPLATERS' SOCIETY—37th Annual Convention, Hotel Statler, Boston, Mass.

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OUR READERS SAY

Short-Beam "K" Factor

To the Editor:

After comparing "Accurate Calculation of Bending Strength" by Stanley J. Weiss in the September 1949 issue and "Overstrength of Short Bending Members" by Frederick L. Ryder in the November 1948 issue, I have a question to raise.

In Mr. Ryder's article, he utilizes the curvature correction factor K and makes reference to F. B. Seely's *Advanced Mechanics of Materials*. Would it be possible to publish the equation for determining values of this factor?

—A. V. LAVEN
Walnut Creek, California

Ed—In calculating values for the correction factor K used in the formula

$$s = K\left(\frac{Mc}{I}\right)$$

for pure bending stresses in short, curved members, Mr. Seeley uses the expression

$$K = \frac{\frac{M}{aR}\left(1 + \frac{1}{Z} \times \frac{c}{R+c}\right)}{\frac{Mc}{I}}$$

where:

I = moment of inertia of section, in.^{4}
M = moment, in-lb
a = cross-sectional area, sq in.
c = distance from center to outer fibre, in.
R = mean radius of curvature, in.
Z = characteristic of section

For circular sections

$$Z = -1 + 2\left(\frac{R}{c}\right)^2 - 2\left(\frac{R}{c}\right) \times \sqrt{\left(\frac{R}{c}\right)^2 - 1}$$

The value for K does not become appreciably high unless

$$\frac{R}{c} \leq 2.0$$

More on Gear Ratios

To the Editor:

The article by Leon N. Canick, "Calculation of a Practical Gear Ratio Approximately Equal to a Given Decimal", as it appeared in the January PRODUCT ENGINEERING, page 112, indicates that the method of continued fractions would always give an approx-

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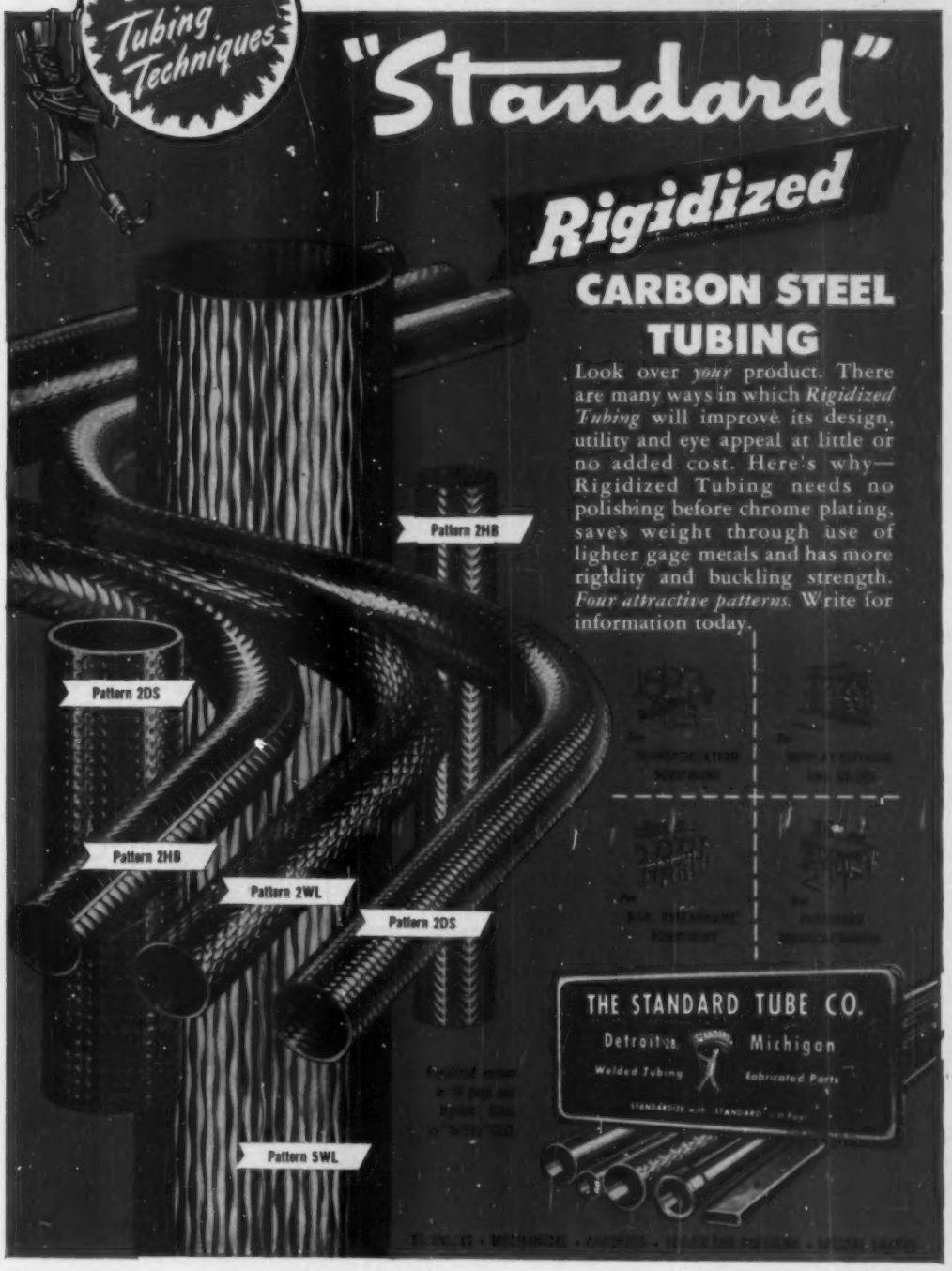

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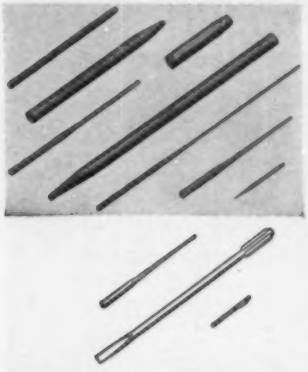

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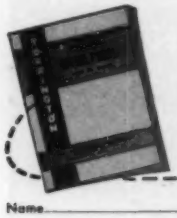

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imate ratio to the usual limits of accuracy required; that is, a difference in the computed ratio of not more than two units in the fifth decimal place. There are a great many decimal ratios that cannot be found by the method of continued fractions. This method has been superseded by using a table of logarithms of decimal ratios for change gears for four-gear trains from 16 to 120 teeth (see Machinery's Handbook).

The following will illustrate the degree of accuracy obtained by each method. Take the example of finding the change gears to obtain the ratio

$$\frac{251}{93} = 2.69892$$

By continued fractions, we get the principal convergents, as follows:

$$\begin{array}{r|l} 93 & 251 \;\; 2 = Q_1 \\ 186 & \\ \hline 65 & 93 \;\; 1 = Q_2 \\ 65 & \\ \hline 28 & 65 \;\; 2 = Q_3 \\ 56 & \\ \hline 9 & 28 \;\; 3 = Q_4 \\ 27 & \\ \hline 1 & 9 \;\; 9 = Q_5 \\ 9 & \\ \hline 0 & \end{array}$$

Principal Convergents								
nth convergent $= \frac{N_n}{D_n} = \frac{Q_n N_{n-1} + N_{n-2}}{Q_n D_{n-1} + D_{n-2}}$								
Number of quotient = n	-1	0	1	2	3	4	5	
Quotient = Q			2	1	2	3	9	
Numerator of convergent = N	0	1	2	3	8	27	251	
Denominator of convergent = D	1	0	1	1	3	10	93	

Intermediate Convergents										
Intermediate convergents between Q_n and $Q_{n-1} = \frac{N_{n-2} + k N_{n-1}}{D_{n-2} + k D_{n-1}}$										
k			1	2	3	4	5	6	7	8	9
N	8	27	35	62	89	116	143	170	197	224	251
D	3	10	13	23	33	43	53	63	73	83	93

Since none of the principal convergents will give the desired ratio, we can find another series of convergents, intermediate between any two principal convergents, if the quotient Q_n from which the last one of the two principal convergents was derived is greater than *one*. The number by which this quotient exceeds *one* will be the number of intermediate convergents we can find between any two consecutive principal convergents. In this case, we can find eight more convergents between

$$\frac{N_4}{D_4} = \frac{27}{10} \text{ and } \frac{N_5}{D_5} = \frac{251}{93}$$

because Q_5 equals *nine*, which is *eight* in excess of *one*. From the table of intermediate convergents, we find none that will give the desired ratio. Therefore, the method of continued fractions fails to give a suitable ratio within the required limit of accuracy.

By using the Logarithms of Decimal Ratios, we find a four-gear train as follows: divide the logarithm of the

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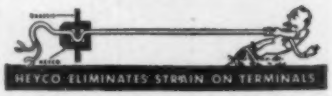

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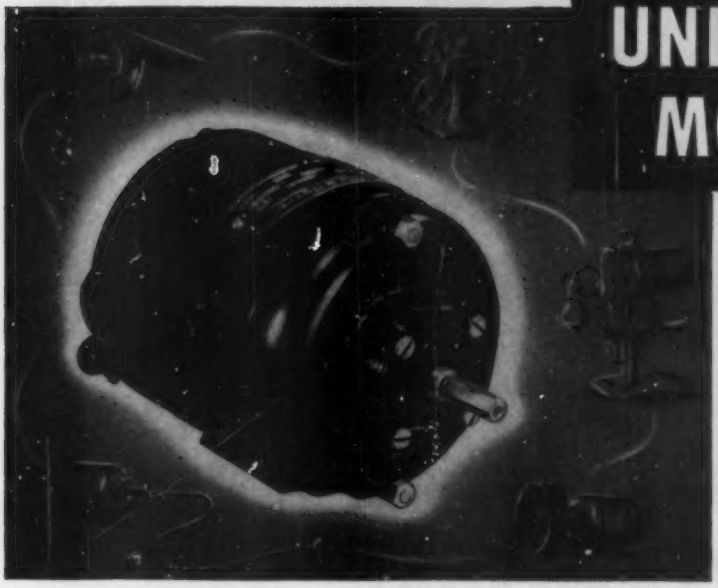

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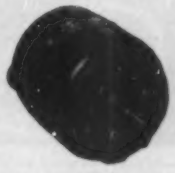

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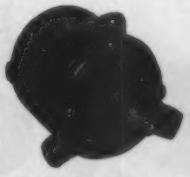

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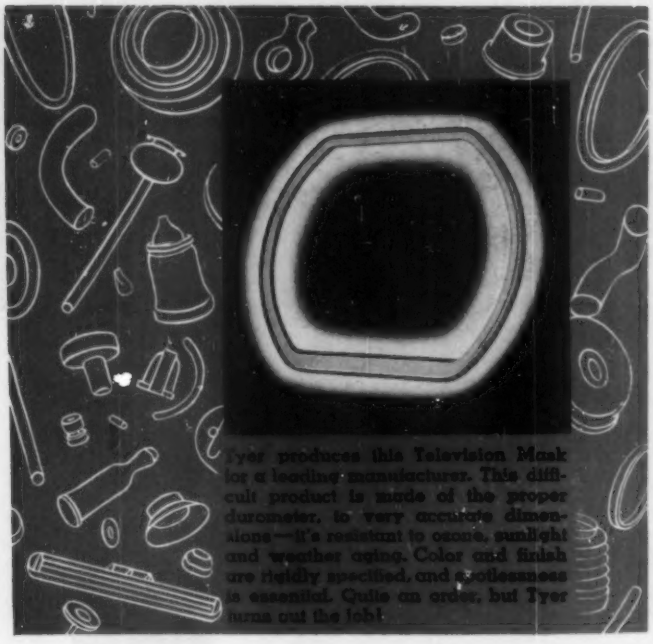
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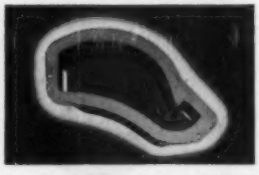

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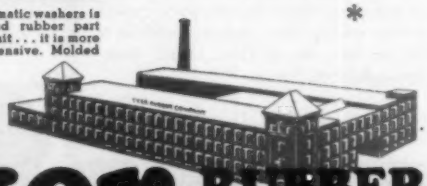

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ratio 251/93 by *two* to obtain two equal gear ratios. It is advisable to have the gear ratios as nearly equal as possible.

$$\log \frac{251}{93} = \log 2.69892 = 0.431191$$

and

$$(\log 2.69892) \div 2 = 0.215595$$

From the table of ratios, we find the logarithm of the nearest ratio to be

$$\log \frac{70}{43} = 0.211630$$

Subtracting this logarithm from the logarithm of the ratio, we find the logarithm 0.219561.

From the table we obtain

$$\log \frac{63}{38} = 0.219557$$

which is nearly equal to the logarithm 0.219561.

Checking these gear ratios, we find

$$\frac{70}{43} \times \frac{63}{38} = 2.69890$$

an error of 0.00002 in the given ratio, which is within the limit of accuracy required.

For the ratio 3.142, given in the article, we find

$$\log 3.142 = 0.497206$$

$$\log \frac{73}{39} \text{ (from table)} = \underline{0.272258}$$

$$0.224948$$

$$\log \frac{94}{56} \text{ (from table)} = 0.224940$$

Checking these gear ratios, we find

$$\frac{73}{39} \times \frac{94}{56} = 3.14201$$

an error of 0.00001 in the given ratio.

—W. W. JOHNSON
Cleveland, Ohio

Where Can I Get It?

He Guessed It

To the Editor:

We are extremely desirous of obtaining information regarding some substance for dipping or painting aluminum tanks to act as insulation against 600-F temperatures for periods of three or four minutes.

A material that we thought of in this connection is Teflon in a solution of volatile solvent from which the solvent vaporizes, leaving a film of Teflon.

If any of your advertisers or affiliated companies have experience using a process similar to that outlined above,

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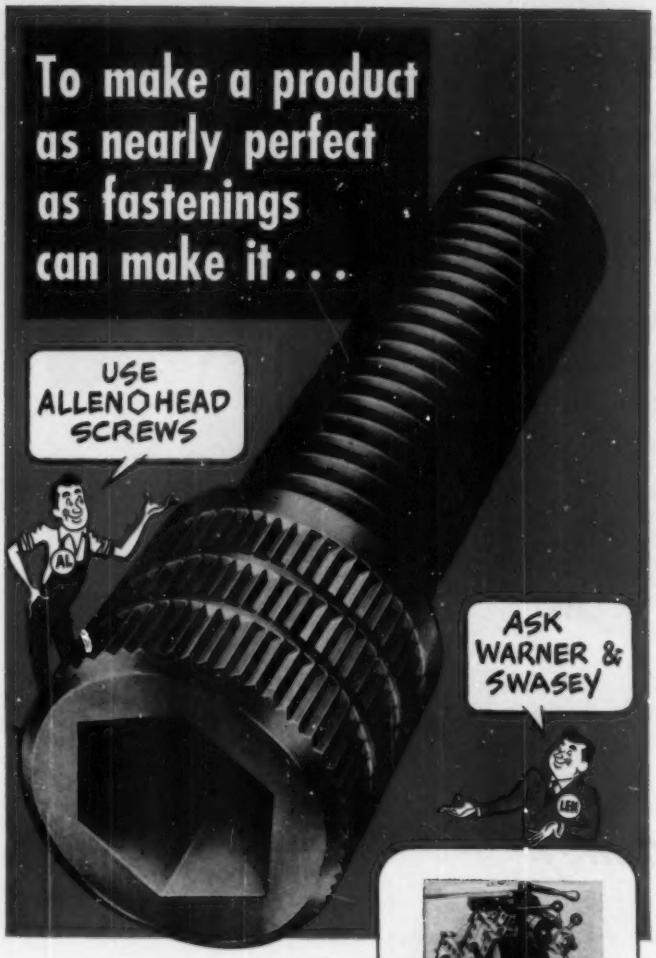

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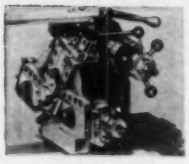

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we would appreciate any information they may be able to give us.

—V. E. UNDERWOOD
The Johns Hopkins University

Ed--Mr. Underwood hit the nail right on the head. DuPont's fluorine plastic, Teflon, is now available in granulated form and can be applied as a spray solution. Mr. D. G. Fertman of the Polychemicals Sales Department, E. I. DuPont deNemours and Company, Wilmington 98, Delaware can supply details on this process.

Nickel Alloy

To the Editor:

In the Highlights section of PRODUCT ENGINEERING I find a note concerning a nickel alloy, devoid of copper and iron, that is highly corrosion resistant, has good machining properties and freedom from seizing or galling.

I would appreciate receiving complete information on this alloy, including the supplier.

—RONALD B. MCKINNIS
The Girdler Corp.

Ed—You should contact the Waukesha Foundry Co., at Waukesha, Wisconsin.

Boron

To the Editor:

In the October, 1949 issue of PRODUCT ENGINEERING on page 3 there is mention of "Boron" and its effect on cast iron. We would like very much to receive more information regarding this alloy because we make quite a number of castings in our Grey Iron Foundry which require hardness and depth of chill. W. J. MITCHELL
Cushman Motor Works, Inc.

Ed—For more information we suggest that you contact the Bureau of Standards, Washington, D. C.

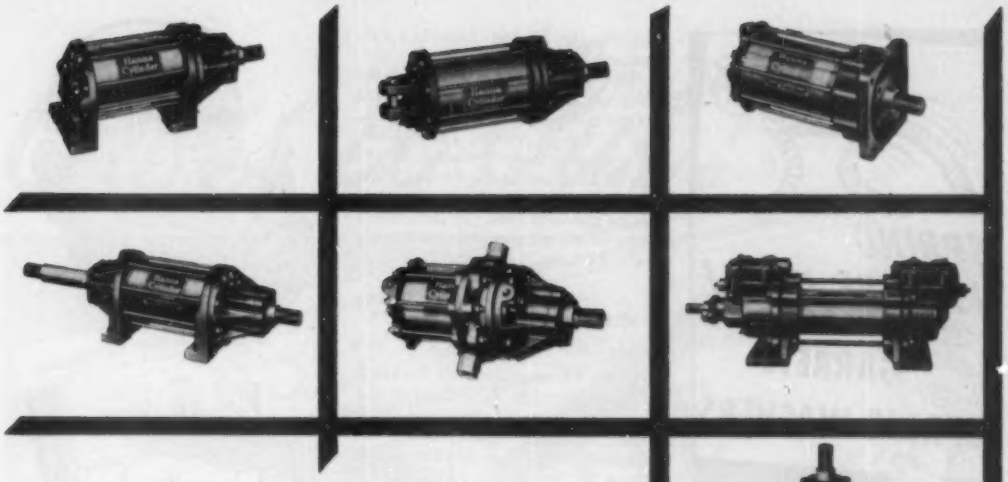
Mineral Oils Do the Trick

To the Editor:

Please send more information on the process in which steel is prepolished, coated with a lacquer solution and then formed as described in the Highlights section of your January 1950 issue.

I would also like to know what kinds of lubricants are recommended for dies in which aluminum sheets are formed. —LOREN WILSON
Los Gatos, California

Ed—Further information regarding the prepolishing of sheet steel can be obtained from the Standard Steel Spring & Bumper Company, Coraop-



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We suggest that you contact the office of Standard Oil of California nearest to you or E. F. Houghton & Co., 303 W Lehigh Avenue, Philadelphia, Pa. for information relating to the type of lubricants to use on dies while forming aluminum sheets. Mineral oils are generally used. In cases where severe draws are required, mutton tallow and paraffin is suitable.

Eastern Licensee

To the Editor:

In the February issue of PRODUCT ENGINEERING, Mr. R. F. Dyer of the Tennessee Eastman Corporation asked where he might obtain further information regarding the Electrofilm process for applying a thin film of graphite to metallic and nonmetallic surfaces.

I would like to inform Mr. Dyer and anyone else who might be interested that Allen Aircraft Products, Incorporated of Ravenna, Ohio have been licensed by the Electrofilm Corporation, North Hollywood, California to apply this process.—JACK F. KOHL
Allen Aircraft Products, Inc.

Ed—This will be good news for many of our 13,000 readers east of the Mississippi River.

Electrical Alloy

To the Editor:

I am faced with the problem of finding a special alloy having high electrical resistivity and the property of retaining stable resistance values over a wide temperature range. Could you suggest some company that makes such a material? —J. W. C.
Newark, N. J.

Ed—Try the Driver-Harris Company, Harrison, New Jersey. They make a nickelbase alloy called Karma which has a temperature coefficient of resistance of 0.0000018 (max) per deg. C between 20 and 100 Centigrade.

Spherical Shot

To the Editor:

Would you kindly advise where I might procure further information on the subject of Spherical Shot as covered in your item on page 5 of the January PRODUCT ENGINEERING?
—S. J. DICKINSON
American Smelting and Refining Co.

Ed—Try the Metal Industry of London, Cassier Ltd., Borset House, Stanford St., London S.E. 1, England.

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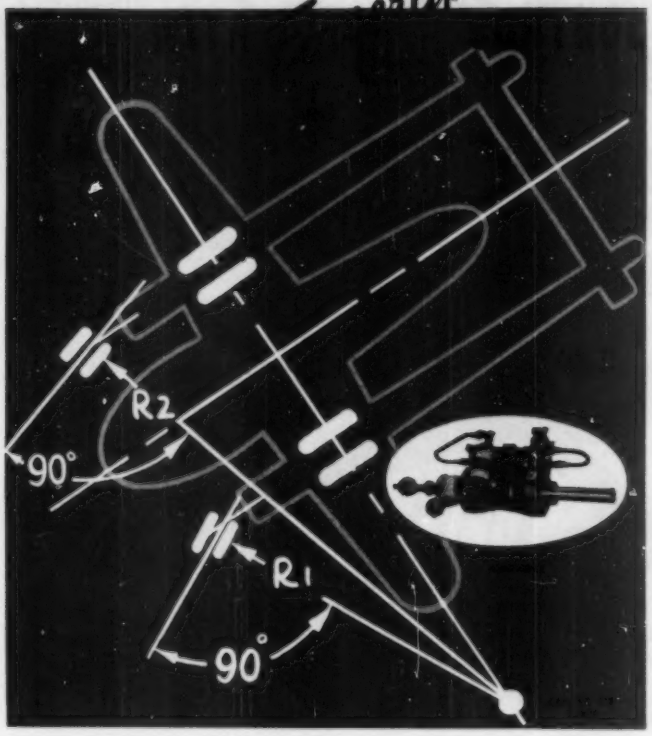
STEERING TONS



. . . solved by Air Associates for the quadricycle 25-ton Fairchild Pack-Plane. Air Associates met the problem of steering the widely separated nose wheels, by producing the differential steer system illustrated above. In engineering this unique mechanism, we developed an ingenious hydraulic follow-up circuit to govern the movement of the nose wheels *differentially!* This system incorporates compensating thermolators and lock valves to assure constant shimmy damping in case of hydraulic line fractures.

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NEW BOOKS

Weld Design

HARRY D. CHURCHILL, *Professor of Engineering Mechanics, Case Institute of Technology, and* JOHN B. AUSTIN, *Welding Engineer, Republic Structural Iron Works.* 216 *pages,* 5¾ x 8¼ *in. Published by Prentice-Hall, Inc., New York, N. Y.* $6.65.

Most machine design textbooks have thoroughly described the design of cast machine bases, but there is very little information available on the welded type of base. Since the process of fabricating machine bases by arc welding is being applied to many different types of design, there has been a need for good information on welding design. The authors have tried to cover the subject from the most practical and theoretical standpoint. They also felt that the designer should have a thorough understanding of the material that enters the machine base construction, and a clear understanding of the many methods of processing plates and structural shapes.

Chapters cover stress analysis and design data, design of arc-welded machine bases, application of welded design principles, welding specifications, procedure and processes, flame cutting, and cost estimating.

Transformer Principles And Practice

J. B. GIBBS, *Design Engineer, Westinghouse Electric Corp. Revised second edition.* 6 x 9 *in.,* 236 *pages. Published by McGraw-Hill Book Co., Inc.,* 330 *W. 42nd St., New York* 18, *N. Y.* $3.50.

This book deals with all aspects of the construction and use of transformers, including underlying principles, applications, connection, testing, care and economics. Mathematics is avoided in a well-illustrated simple treatment that covers both the "why" and "how" of transformers.

Beginning with an introduction to the fundamentals of transformer performance and construction, the book goes on to describe many particular types of transformers, large and small, for various purposes such as instruments. Methods of connecting transformers are described, as are special applications of standard transformers, including phase transformation. Pointers on polarity, ratio adjustment, transformer oil, mechanical forces, and

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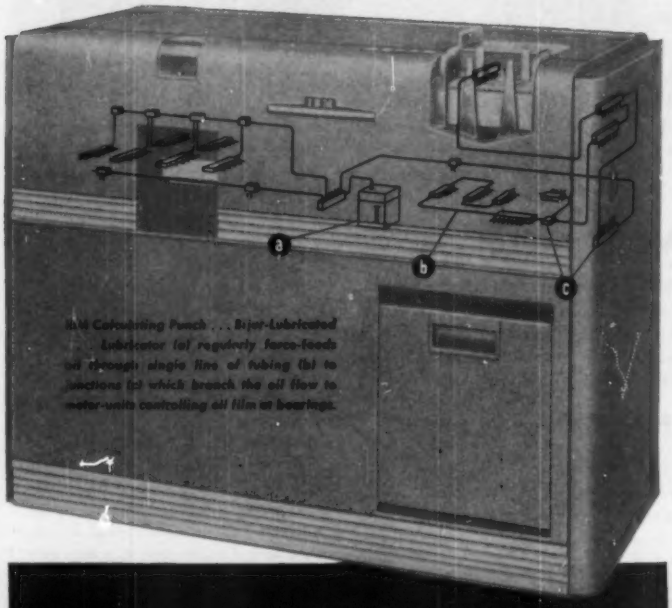

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other subjects necessary to a workable understanding of transformers are also included. Numerous other topics emphasizing practical methods of utilizing, testing and maintaining transformers round out this practical manual.

This revised second edition includes a new chapter on current-limiting reactors and many new illustrations showing up-to-date construction where improvements have been made on former practices.

Rayon

JOSEPH LEEMING. 5½ x 8½ *in.*, 203 *pages. Published by the Chemical Publishing Co., Inc., 26 Court St., Brooklyn, N. Y.* $5.75.

This is a semi technical book which summarizes in an interesting and readable style the principal facts about the properties, methods of manufacture and uses of rayon, the first of the synthetic fibers. It tells the story of the research that led to the discovery of rayon and the important development work that achieved the commercial success of rayon materials. It presents a clear picture of the position of rayon in the present-day world of textiles.

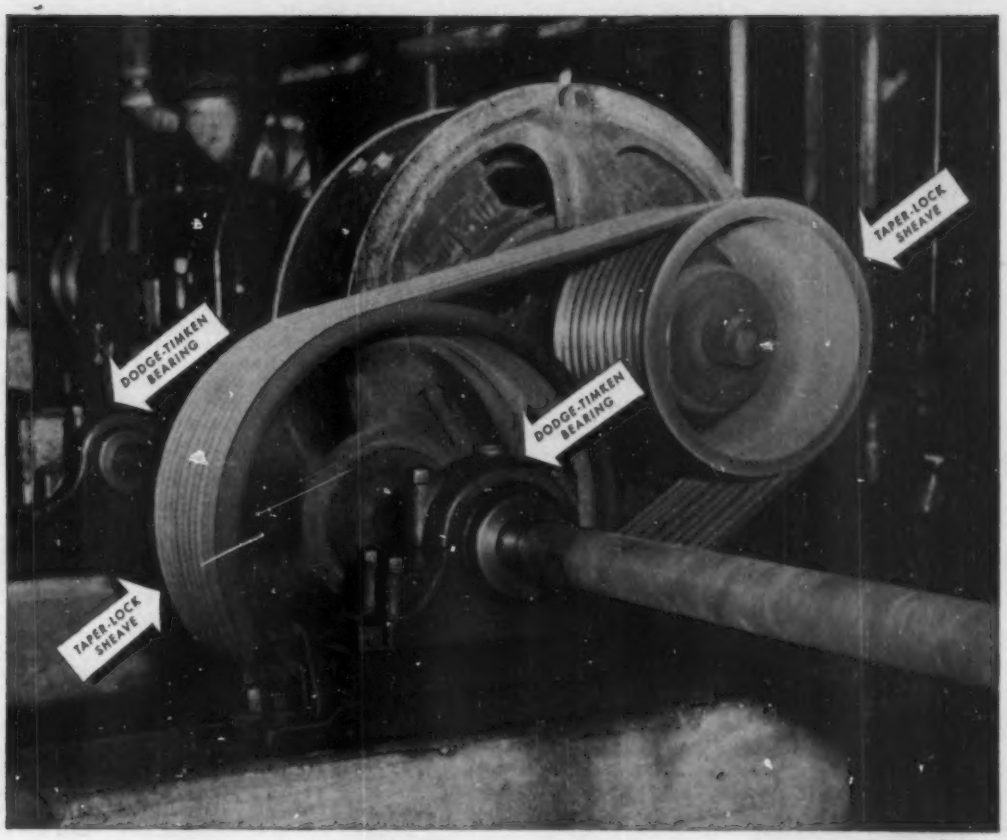
An important feature of the book is a detailed glossary which gives concise but descriptive definitions of rayon fabrics, and of general terms used in the rayon industry. Clear photographs of the various manufacturing steps and of the typical rayon fabrics add to the instructive value of the book.

Elastomers and Plastomers

Edited by R. HOUWINK, *External Lecturer in the Technical University at Delft (Netherlands). Published by Elsevier Publishing Co., Inc., 215 Fourth Ave., New York 3, N. Y. Volume I*—495 *pages,* 7 x 10 *in.,* $7; *Volume II*—515 *pages,* 7 x 10 *in.,* $9.

These are the first two volumes of a three-volume series on synthetic high polymers. Volume I covers general theory, and Volume II is concerned with manufacture, properties and applications. Chapters in each of the volumes have been contributed by recognized authorities in each particular field.

The title of the series "Elastomers and Plastomers" has been chosen to differentiate between the elastic and the relatively rigid synthetic polymers. Volume I on general theory includes discussions of: Economic aspects, organic chemistry, reaction kinetics, molecular constitution, mechanical properties, physics and structure, electrophysics, mechanical operations, polymer-liquid interactions and plas-



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ticizers. Although the first volume goes into the chemistry of polymers quite intensively, it is recommended for those engineers intending to specialize in the plastics field. This volume contains a valuable discussion of the effect of chemical structure on physical and mechanical properties of plastics.

Volume II is a more specific discussion of the various plastic materials, including: Phenol-formaldehyde plastics, phenol-formaldehyde lacquers, synthetic resin ion exchangers, urea and melamine resins, polymers from ethylene derivatives, the cellulose derivatives, protein plastics, synthetic polyamides, silicone polymers, alkyd resins, natural resins and their derivatives, derivatives of natural rubber, synthetic rubbers and asphalts.

Giant Brains or Machines That Think

EDMUND CALLIS BERKELEY, *Consultant in Modern Technology, President, E. C. Berkeley and Associates.* *270 pages, 5¾ x 8½ in. Published by John Wiley & Sons, Inc., New York, N. Y.* $4.

Out of the rash of articles and literature on calculating machines there has at last emerged a book that clearly explains the theory, construction and operation of the various types of computing machines. The author, who has a thorough knowledge of automatic computers and has designed some of the intricate circuits for the Aiken Mark II Relay Calculator, is now a consultant in the field of applications, marketing and uses of automatic machinery for handling information and computing.

Although the title carries implications that many engineers and scientists resent, and although the author spends a chapter discussing the similarity between automatic computers and the human brain, the discussion on the operational theory and method of feeding information into the machines is excellent. The book is well within the grasp of any graduate engineer, and at the same time it is not a naive, "oh my" discussion.

The author first explains how to design a very simple automatic computer, and how its range of information can be extended and how methods can be devised for storing the information. There is a good discussion on how computing circuits are arranged so that this machine can perform simple operations.

After developing the nature of this simple machine, the author discusses punch card calculating machines and their ways of handling information.

Cancelling "Holidays" in a COATING'S CALENDAR

Look closely at the picture above, and you'll see a spark jumping from the metal test panel to the electrode in the technician's left hand.

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Sometimes these "holidays" aren't visible to the naked eye. So Flintkote researchers use this method of testing electrically to be *certain* that the coatings tested meet the conditions for which they were formulated. When the tell-tale spark appears . . . back the coating goes for further development until it passes every test with flying colors.

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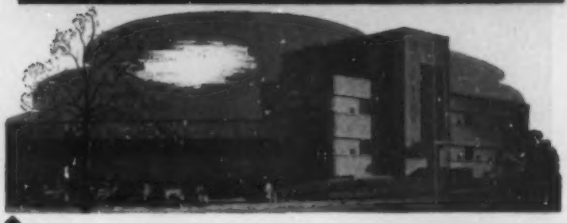
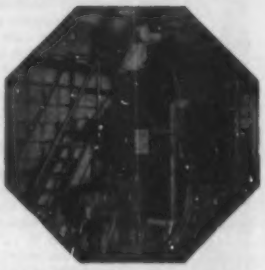


⬆ One or more of 24 separate laboratories constantly evaluate Flintkote products step by step from raw materials to field performance, from initial development to mass production. Both Company and Customers profit by this *insurance from research*.



This "pilot scale" ribbon type mixer ➡ enables the laboratory to reproduce production conditions quickly and accurately for research and testing of a variety of asphalt mastics.

⬅ Scientific equipment in use here permits complete analyses when only minute quantities, sometimes no larger than a pinhead, are available. Techniques like this assure purity, reduce cost, speed operation and increase accuracy in the Flintkote Laboratories.

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He then shifts to machines that move information expressed as measurements, such as MIT's Differential Analyzer No. 2. Chapter 6 covers Harvard's IBM Automatic Sequence Controlled Calculator. Chapter 7 covers Moore School's ENIAC, which is capable of 5,000 additions a second. Bell Laboratory's General Purpose Relay Calculator is described in Chapter 8; The Kalon-Burkhart Logical Truth Calculator, which is an extremely ingenious electrical instrument for logical reasoning, is then described. In final chapters, the author discusses the new developments just over the horizon, and in the last chapter he includes an essay on the control of machines that think and how society may control them.

There are almost 20 pages of references to literature concerned with automatic computing machinery. These references cover both popular and scientific writings. Any engineer who wants to know more about computing machinery, the theory underlying them, their construction and operation, and an appraisal of their potentialities will find this book to be first rate.

Principles of A New Energy Mechanics

DR. JAKOB MANDELKER, *Asst. Professor of Mechanics, Georgia Institute of Technology.* 5¼ x 9¼ *in., 73 pages. Published by Philosophical Library,* 15 *E. 40th St., New York* 16, *N. Y.* $3.75.

The mechanics presented in this book, to which the author has given the name "energy mechanics", constitutes a basically new conception of that whole body of science. This new mechanics has been evolved from the same basic relations as Einstein's special theory of relativity, though not in the sense of his so-called postulates.

The central inertia notion of classical mechanics, the mass m, has been replaced in this mechanics by the superior energy conception of matter, mc^2. This important conception imparts its own higher order value to the new mechanics which conforms fully with the relativity principle, includes classical mechanics as a particular limiting case, and turns out, moreover, to be valid for high velocities.

The most significant result here is the new kinetic energy formula of a definite upper limit—something wholly unsuspected hitherto—which coincides exactly with the value for the radiating energy. While the new formula shows the classical value in the first approximation, it is entirely different from Einstein's kinetic energy formula.

In this new mechanics the result of

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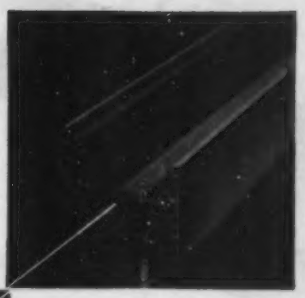

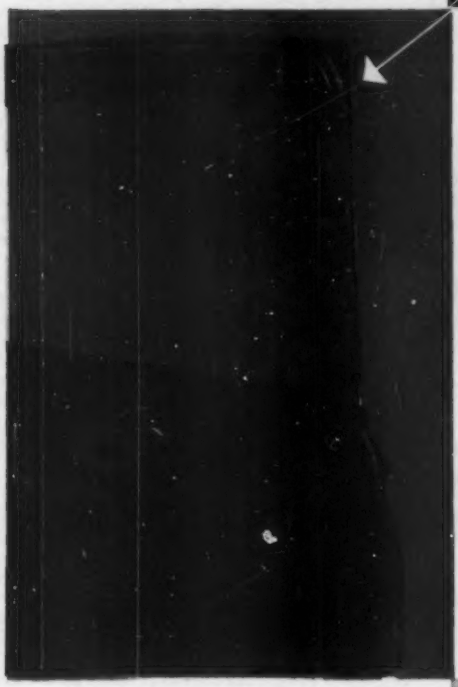

Suppose your car doors shut metal to metal! What a *crash* when you slammed them. What squeaks, rattles and groans as you drove along! And you'd get wet. You would freeze. It would *always* be drafty.

But a sponge rubber product seals out drafts, temperature and moisture . . . cushions shock and vibration . . . absorbs noise. Doors shut snugly and quietly, slam after slam after slam.

If you have a vibration, insulation, cushioning, gasketing, sealing or sound damping problem, think about *Spongex*. Cellular rubber does not become a "product" until you make it one in *your* application. We welcome new problems.

Illustration below—The vertical cord is decorative and functional. This fabric covered Spongex cord seals out drafts.

On door and body are Spongex pieces molded around metal to afford reinforcement, rigidity and mechanical fastening.

Spongex forms shown are from molds designed by us and owned by our customers. As such they are not offered for sale. Similar products can be molded to your requirements in molds designed for you.

TECHNICAL BULLETIN ON SPONGE RUBBER AVAILABLE ON REQUEST

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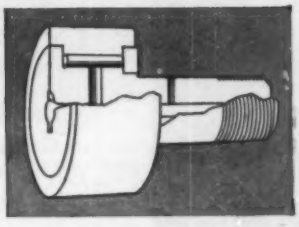

You can see at a glance the ruggedness of construction which enables Multirol CF Series bearings to take repeated shock loads, even at the increased speeds demanded by modern machines. The extra heavy outer race section has a case hardened surface which provides extra wear, and a tougher core to resist shock loads. The inner race and flange, with hardened wear surfaces, are made of a single piece with the stud, preventing any possibility of disassembly in operation. Notice there are no delicate parts or washers anywhere, to break or cause trouble. The many full type small diameter rollers provide extra bearing surface. They are finished to precision limits assuring friction-free operation between the smooth ground raceways. Nearly twenty years successful operation in a variety of installations has proved the quality, construction and workmanship of CF Series Multirol bearings.

For installations where it is necessary to mount the bearing on a shaft, this same design is available in the Cam Yoke Roller (CYR) Series. For complete information about either type write McGill Mfg. Co., Inc., Bearing Division, 201 N. Campbell St., Valparaiso, Indiana. Ask for Bulletins CF-40 or CYR-47.

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precision bearings

Fizeau's experiment is precisely confirmed; furthermore, the Lorentz transition formula appears as a self-evident result, as does the dual character of force for rest and for motion. The wave-corpuscular aspect of matter is presented in an entirely new light, differing from De Broglie's basic conception; and finally, a satisfactory explanation is given for the half-quantum value of the "zero point" energy according to Schroedinger's wave equation. This is the range of the new energy mechanics.

Electronics in Engineering

W. RYLAND HILL, *Associate Professor of Electrical Engineering at University of Washington. 274 pages, 6 x 9 in. Published by the McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y.* $3.50.

Engineers in all fields of activity, who wish to learn something of electronics and its applications to their problems, will find this book of value in discovering the capabilities of electronic techniques and how electronic instruments work.

Theory, design and applications are covered in a well balanced presentation. Wherever possible, a complete graphical picture is presented with coordinated circuit diagrams and wave forms as a supplement to the text. The mathematical approach is not avoided, but is usually accompanied by a graphical analysis and computations employing typical circuit values. Descriptions of the various electronic devices are followed by a discussion of applications that illustrate their possibilties.

Chapter headings are as follows: Electrons, ions, and photons; practical emitters and diodes; single-phase rectifier circuits; grid-controlled vacuum tubes; gas-filled tubes; photosensitive devices; electronic control circuits; polyphase rectifiers; practical amplifier circuits; feedback; resonance and tuned amplifiers; oscillators; amplitude modulation and demodulation; the cathode-ray oscilloscope; tranducers; and the vacuum-tube voltmeter.

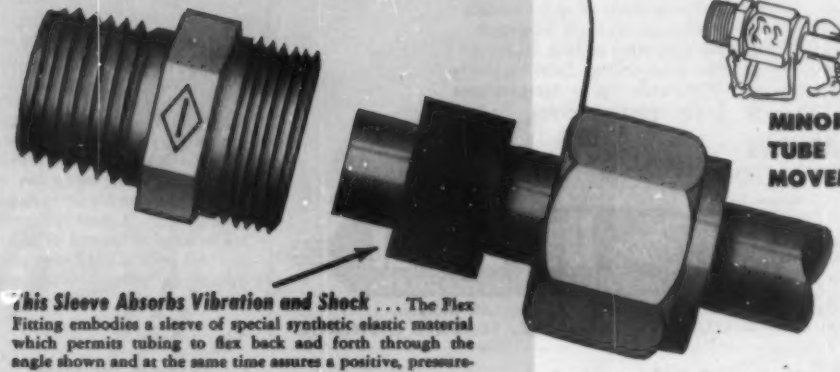
Electric Resistance Strain Gauges

W. B. DOBIE, *M. Sc., Research Department, C. A. Pearson & Co. Ltd., and* PETER C. G. ISAAC, *Lecturer in Civil Engineering, University of Durham. 112 pages, 6 x 8 in. Published by The MacMillan Co. 60 Fifth Ave., New York, N. Y.* $3.50.

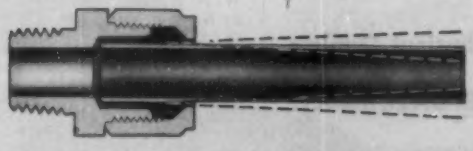
At this writing there is no comprehensive American publication that describes the use and application of the resistance wire strain gage. Two

IMPERIAL FLEX FITTINGS

for connecting tubing where there is



This Sleeve Absorbs Vibration and Shock . . . The Flex Fitting embodies a sleeve of special synthetic elastic material which permits tubing to flex back and forth through the angle shown and at the same time assures a positive, pressure-tight seal.



Flex Fitting Makes Joints Virtually Indestructible by Vibration . . . On tests where ordinary fittings failed after 73,000 cycles of vibration, Imperial Flex Fittings have withstood over 20,000,000 cycles without failure as indicated in the chart below:

COMPARATIVE VIBRATION TEST

NUMBER OF VIBRATIONS IN CYCLES
20,000,000
Flare Fitting failed after 72,450 cycles
Compression Fitting failed after 79,350 cycles
Hi-Duty Fitting failed after 401,925 cycles
FLEX FITTING showed no signs of failure after . . . 21,424,500 cycles

For All Kinds of Tubing . . . Imperial Flex Fittings can be used with all types of seamed and seamless metal tubing, including copper, aluminum, thin-wall steel, monel, stainless steel, etc.

Easy to Install . . . All that is necessary is to slip nut and Flex sleeve over tubing. Then insert tubing into fitting body as far as it will go, and assemble. On sizes larger than ½" O.D. and where higher pressures are involved, end of tubing should be belled slightly.

Proved by Extensive Use in the Field . . . Used as standard equipment on trucks, tractors, diesel engines, oil filter connections, heavy power equipment, machinery, etc.

CATALOG No. 344-B gives complete engineering data on Flex Fittings including types, sizes, dimensions, specifications and applications. *Write for your copy.*

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5 New Models
ask for BULLETIN 525

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IN Size and Spherical Accuracy
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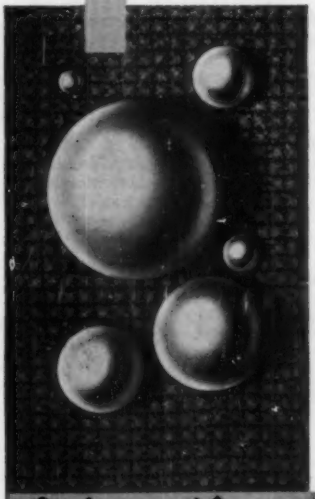
Uniformity—Dependable Physical Quality



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English authors have collected much of the information spread throughout technical literature in Britain and the USA and combined it so that those who want to use strain gages for research or routine investigation will have a ready source for tracing the many references in detail.

Chapters cover strain gage characteristics, the determination of static strains, stress analysis, including elastic properties of a material, complex stress, complex strain, stress analysis from experimental results and gage arrangements. The fourth chapter covers elementary electronics, the fifth, various electronic bridge circuits, the sixth, problems in measuring dynamic strain. The seventh chapter is devoted to the application of strain gages in such fields as residual stress, torque meters, ship-building problems, impact tests, measurement of weight, engine indicators, pressure gages, proving rings, aeronautical applications, reinforced concrete and others. The last chapter covers brittle coatings as a method of stress estimation, which has merit as a preliminary survey for resistance wire applications. A great many references are included at the end of each chapter and this book should serve a valuable purpose for researchers and engineers.

The Science Of Wrinkle Finishing

W. A. WALDIE. 200 *pages. Published by Research Press, Inc.*, 137 *N. Perry St., Dayton, Ohio.* $5.

Book tells what the formulator must do to produce a soft, suede-like finish, or a high metallic gloss. Preparation of surface, spraying, drying and baking are fully described, and application to flexible materials such as paper, fabrics and wood are dealt with in detail. Technical data on polymerization and on drying oils are given special attention.

Machine Tools For Engineers

CHARLES R. HINE, *Assistant Professor of Manufacturing Processes, Rensselaer Polytechnic Institute.* 355 *pages*, 6 x 9 *in. Published by McGraw-Hill Book Co.* 330 *W.* 42 *St., New York, N. Y.* $3.50.

This is the first of two volumes on manufacturing processes, which evolved from the courses developed at Rensselaer Polytechnic Institute. Its aim is to introduce the student to the fundamentals of machine tools and production processes from the viewpoint of the engineer, rather than from that of the machinist who is interested in developing skills. The book

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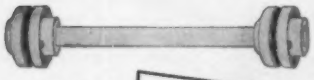

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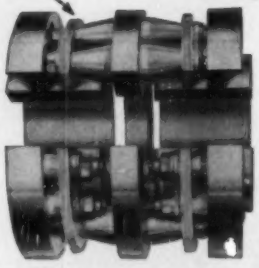

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comprises a descriptive and analytical treatment of all types of machine tools, how they are used, what they can do and what their limitations are. Various chapters cover cutting tools, measurement, the lathe, threads and threading, hone-making, the shaper, the planer, the milling machine, broaching, abrasives and grinding, microfinishes, boring machines, gear making, jig boring, sawing and turret lathes. For its purpose the book appears to be an excellent job.

Production Processes—Their Influence on Design

ROGER W. BOLZ, *Associate Editor, Machine Design.* 568 *pages,* 6¼ x 10 *in. Published by the Penton Publishing Co., Cleveland, Ohio.* $10.00.

This book was obviously written specifically for the benefit of design engineers, although, the presentation is such that the book will be found of definite value by production managers and other manufacturing executives who have anything to do with the selection of manufacturing processes to be employed.

In this first volume the author covers eighteen methods for cutting or removing metal, eight methods of metal forming, eight methods of metal working and forging and two methods, electroforming and metal spraying of metal deposition.

In each case the processes are presented in a broad manner: The character and purpose of the production method under discussion is covered. The types and characteristics of operations, the range of sizes that can be produced or worked upon, the ranges of production speeds and the character of operations for which the given method is especially suited are given. Special techniques used in the various production methods to improve the tooling, speed production or simplify the operations are described.

The author has very wisely omitted any detailed descriptions of the constructions of the machines and their operations. Much of the former are furnished by the many excellent illustrations, both halftones and line cuts.

In addition to giving the production speeds, tolerances and qualities that can be expected of the various processes, the author also gives the general limitations of the various processes and in some cases gives comparisons with the results obtained by other processes.

This book is distinctly not a college textbook as it obviously assumes a general knowledge of metal working equipment. Nor is the book written for machine operators as no detailed designs of rakes, cutting angles and

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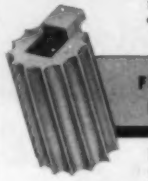

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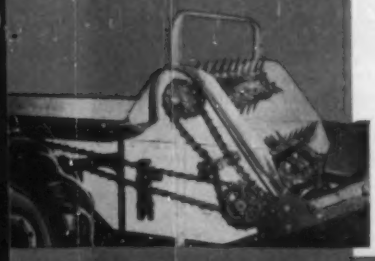

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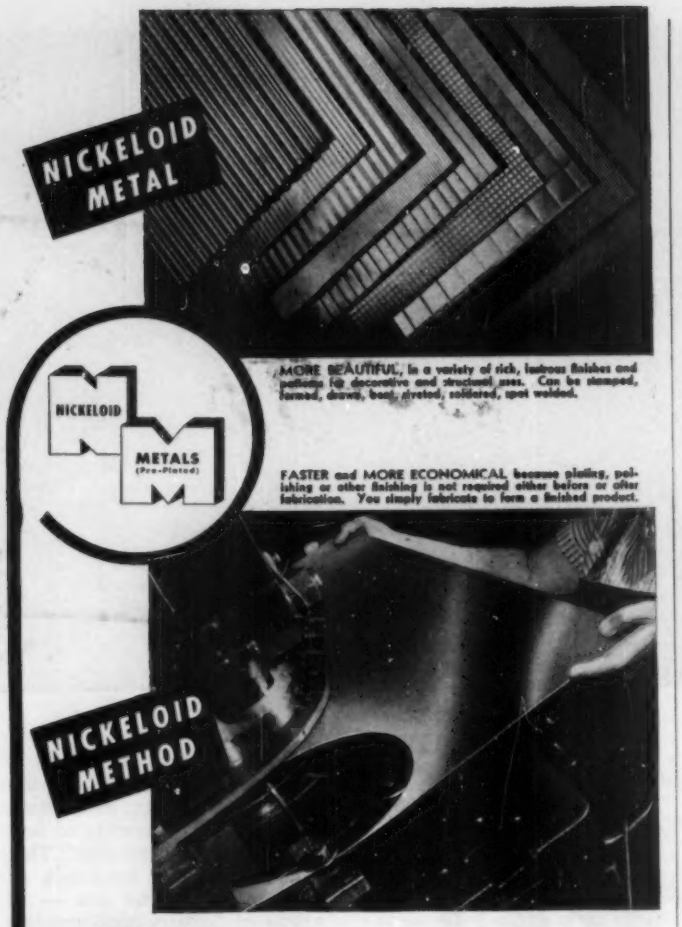
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clearances are given. Thus, the book is devoted entirely to the interests of designers and production engineers who can profit through its use as a reference book. Design engineers will find the book valuable as a ready reference which they can use to check the design of the part to make sure that it is suitable for the method of manufacture that is to be employed. Or the designer may use this volume when studying the possibility of redesigning the part to be produced by another manufacturing method, and in that manner possibly reduce costs.

The basis of the book is a series of articles written by the author and published in the magazine *Machine Design*. It is contemplated that a second volume covering methods not included in this first volume will be prepared and published.

After two short chapters in which the author discusses mass production and production design, the following production methods are presented: Flame cutting, contour sawing, planing, shaping and slotting, automatic and shape turning, turret lathe machining, automatic screw machining, Swiss automatic machining, production milling, drilling and boring, hobbing, broaching, gear shaper generating, abrasive belt grinding, production grinding, tumbling barrel grinding, honing, lapping, superfinishing, metal spinning, brake forming, roll forming, section contour forming, stamping, deep drawing, rotary swaging and hammering, wire forming, die forging, hot upsetting, die rolling, hot extrusion cold and impact extrusion, cold drawing, cold heading, thread and form rolling electroforming and metal spraying.

Fourier Methods

PHILIP FRANKLIN, *Ph. D., Professor of Mathematics, Massachusetts Institute of Technology.* 5¼ x 8¼ *in., 289 pages. Published by the McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York* 18, *N. Y.* $4.

This book is an introduction to Fourier series and Laplace transforms. Applications to physical problems involving ordinary and partial differential equations are included. The reader is assumed to have a working knowledge of elementary calculus, but where topics of advanced calculus are needed they are developed from the beginning. Thus the discussion may help students and technologists to understand works in their field written in terms of harmonic analysis, complex exponentials, Fourier integrals, Fourier transforms, and Laplace transforms.

The method of Fourier is interpreted here in a broad sense as referring to

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The second chapter discusses averages and root mean square values as a preliminary to Fourier series. The series are found for simple functions by integration and for empirical functions numerically from a schedule for harmonic analysis.

As a preliminary to the solution of specific problems, Chapter 3 treats partial differential equations in a general way. Some simple general solutions as well as some particular solutions of a useful type are found. There is an explanation of the physical significance of the equations governing vibrations, the flow of heat, and the transmission of electricity, as well as Maxwell's equations and their relation to electrostatic fields and electromagnetic waves. The following chapter solves boundary value problems for steady and variable heat flow, transmission lines, vibrating strings, and hollow wave guides.

In the final chapter the operational calculus is developed from the Laplace transform point of view and is applied to finding the transients in linear electrical and mechanical systems.

Patent Practice And Management

ROBERT CALVERT, *Ph.D., Patent Attorney, New York City.* 6¾ x 9¼ *in.,* 371 *pages. Published by Scarsdale Press, Box* 536, *Scarsdale, N. Y.* $5.

The author, who is a practicing patent attorney with long experience as a research laboratory director, presents in this book the management of invention and patents, from the viewpoint of the inventor and the executive. He explains how to obtain patents, how to use them, and how to administer patent policy in such a manner as to stimulate research and invention. Representative problems discussed include what to do with respect to an important development going into commercial use and said not to be obtainable, how to avoid such misuse of patents as to render them unenforceable, advantages and disadvantages of filing foreign applications, special incentives for inventors and executives for service beyond what is

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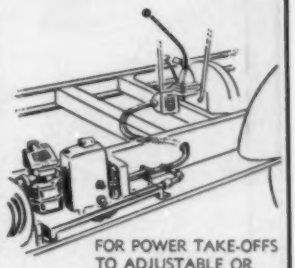

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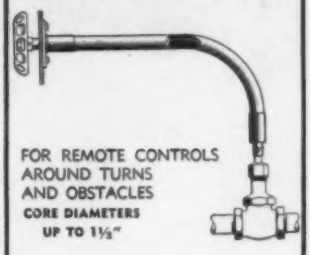

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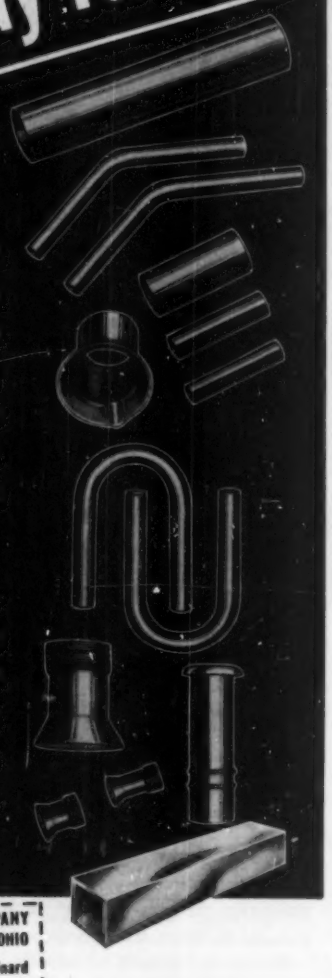

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Patent law is described in some detail as a tool for forming judgment in patent matters. This law is illustrated by representative industrial examples.

Experimental Physical Chemistry

F. DANIELS, J. H. MATHEWS, J. W. WILLIAMS, P. BENDER, G. W. MURPHY and R. A. ALBERTY, *Chemistry Department, University of Wisconsin.* 6¼ x 9¼ *in.*, 568 pages. *Published by the McGraw-Hill Book Co., Inc.*, 330 *W. 42nd St., New York* 18, *N. Y.* $4.50.

This new edition is a thorough revision of a well-known standard work in the field of physical chemistry. Some of the new features that have been added include seven new experiments: Two on radio chemistry; two on chemical kinetics, one each on high polymers, chromatography and gas absorption. The chapter on electronics has been enlarged and brought up to date to take account of the phenomenal growth of electronic circuits in the instruments used in physical chemistry.

Safe Handling Of Radioactive Isotopes

Booklet, 29 pages. Published by U. S. Government Printing Office, Superintendent of Documents, Washington 25, D. C. Fifteen cents.

Handbook gives general safety recommendations to protect scientists and technicians conducting research on radioactive isotopes, industrial workers handling such materials, and the general public. Specific problems discussed are those of personnel, laboratory design and equipment, hazard instrumentation, hazard monitoring, and transportation of isotopes.

Standards for Ball and Roller Bearings and Steel Balls

The Anti-Friction Bearing Manufacturers Association, Inc. Approximately 300 pages, 8½ x 11 in. Published by The Anti-Friction Bearing Manufacturers Association, Inc., 60 East 42nd Street, New York 17, N. Y. $5.

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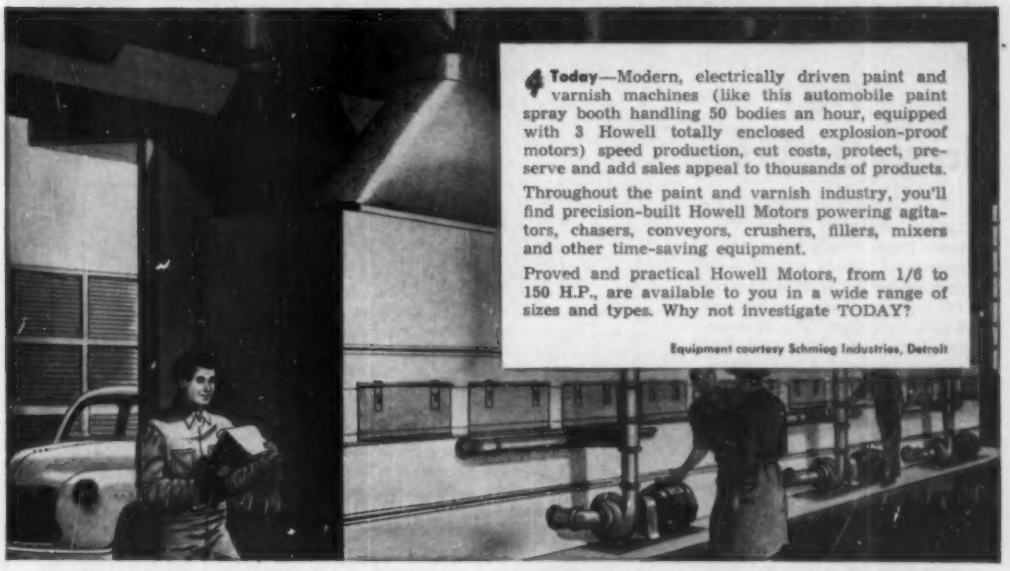

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The publication consists of ten sections. The sections respectively cover AFBMA Standards for:

Terminology and definitions for anti-friction ball and roller bearings and parts.

Boundary dimensions for ball and roller bearings.

Bearing tolerances.

Ball and roller bearing standard gaging practices.

Bearing identification code for anti-friction ball and roller bearings.

Recommended practice for domestic and export packaging of anti-friction ball bearings.

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Steel balls.

Engineering Mechanics

A. HIGDON, *Professor of Theoretical and Applied Mechanics at Iowa State College; and* W. B. STILES, *Professor of Engineering Mechanics and Associate Director, Engineering Experiment Station, at University of Arkansas.* 505 *pages,* 6 x 9 *in. Published by Prentice-Hall, Inc.,* 70 *Fifth Ave., New York* 11, *N. Y.* $6.65.

This volume is the first publication in Prentice-Hall's new Civil Engineering and Engineering Mechanics series, edited by Professor N. M. Newmark of the University of Illinois.

In this text emphasis is placed on an understanding of the principles employed in the solution of problems rather than on a rote process of substitution in numerous formulas. The aim of the authors is to focus the students' attention to the fact that mechanics is a prelude to engineering design. Fundamental principles are stressed and the text is designed to develop the ability to apply them.

Equal consideration is given to statics and dynamics. Wherever possible, an action is illustrated by the use of free body diagrams or other pictorial and semi-graphical aids. These supplement, rather than replace, the application of elementary calculus.

The text is divided into chapter classifications covering: Basic concepts; resultants of force systems; centroids and centers of gravity; equilibrium; friction; moments of inertia; absolute motion; relative motion; force, mass and acceleration; work and energy; impulse and momentum; and mechanical vibrations.

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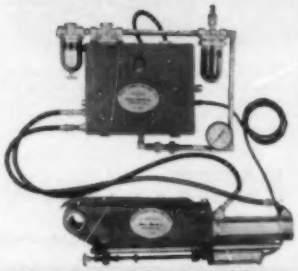

(Above) Standard Beckett Feed and Control Box for drill presses with 1¼" pinion shaft.

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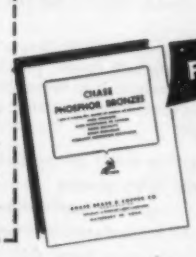

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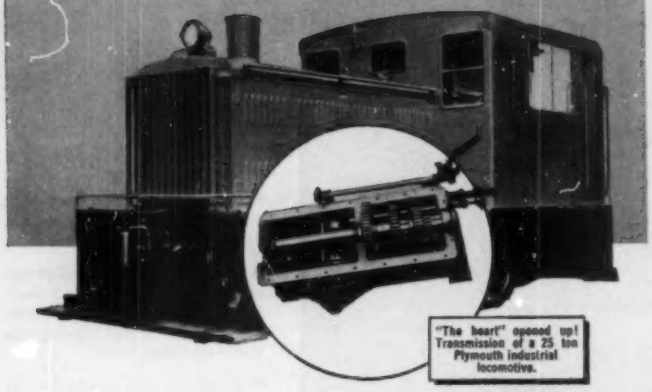

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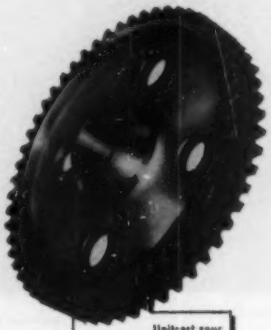

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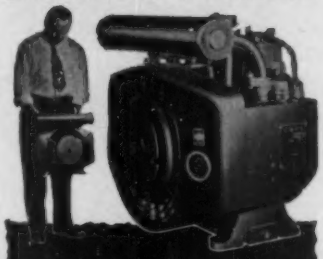

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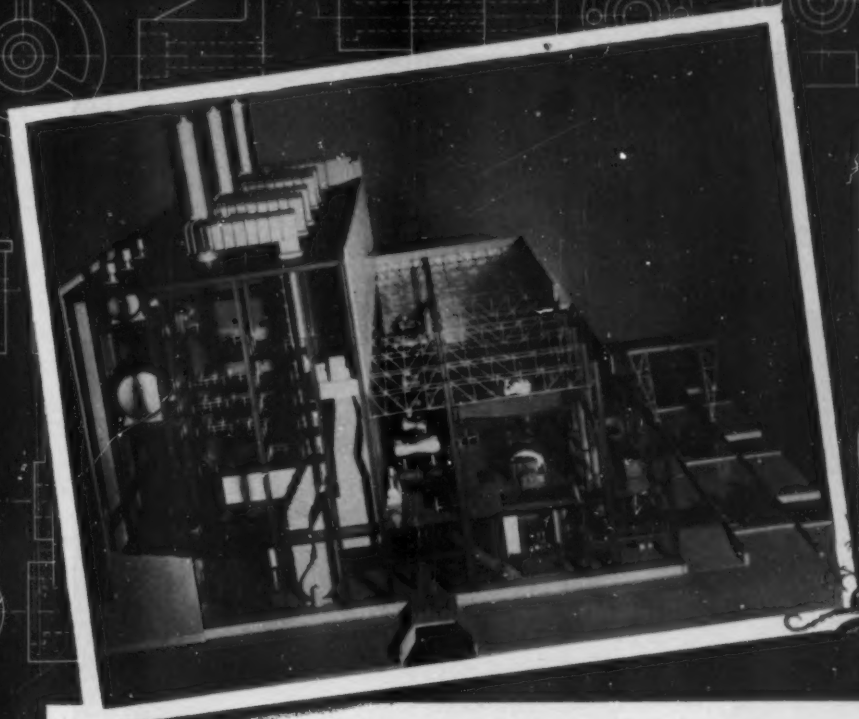

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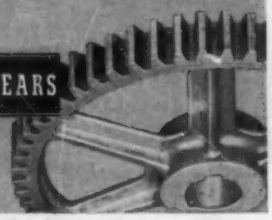

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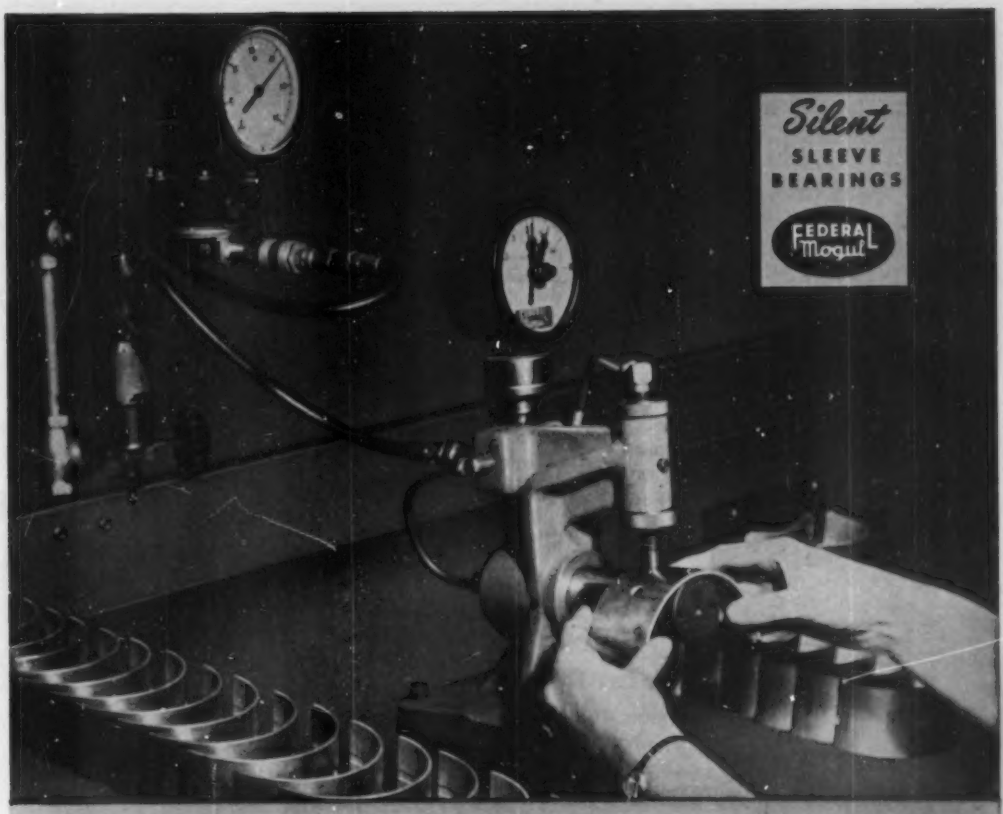

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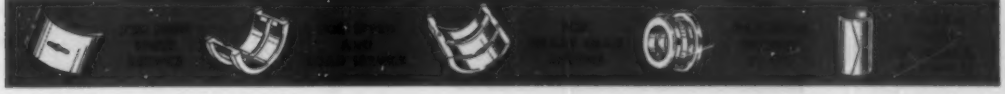

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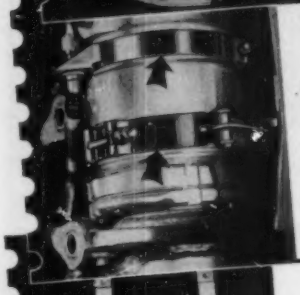

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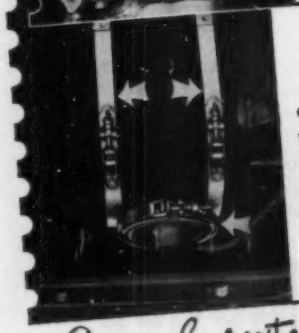

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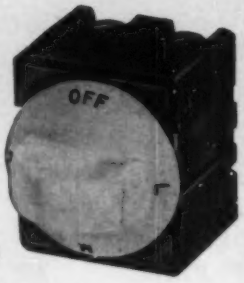

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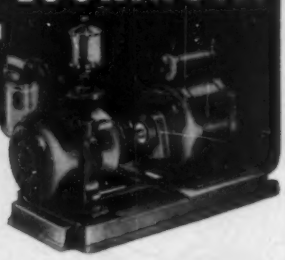

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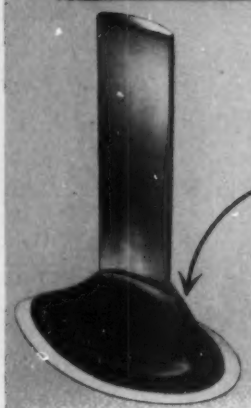

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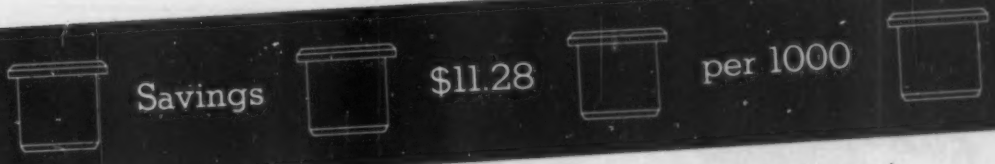

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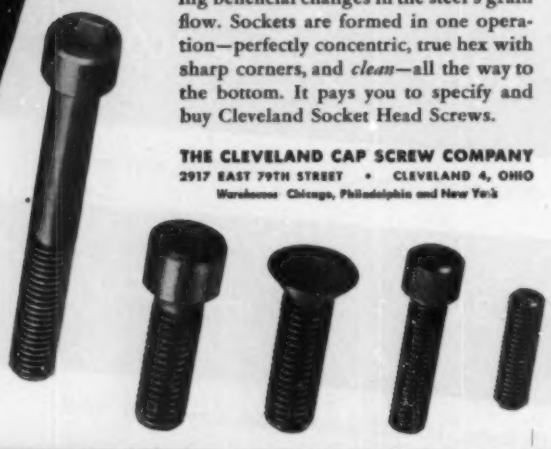

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Ultimate Strength (psi)	73,000	66,000
Elong. in 8" (%)	25	25
Endurance Limit		
Fatigue Strength (psi)	49,000	33,000
Impact Resistance (Charpy Impact—ft. lbs.) Temperature		
80° F	55	36
32° F	43	33
0° F	36	26
—25° F	34	6
—50° F	30	2

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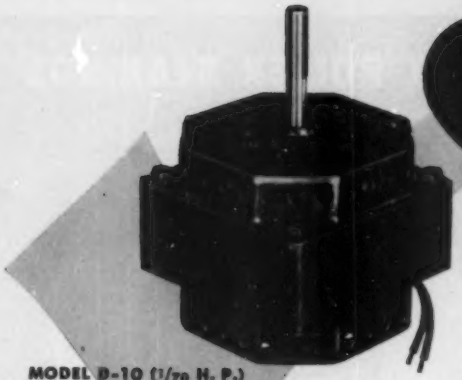

MODEL D-10 (1/70 H. P.)

4-pole, shaded pole induction motor. Free Speed—1740 R.P.M. Locked Rotor Torque—4¾ in. oz.—H.P. at 1500 R.P.M.—1/70; Dimensions: 3⅜" square x 3⅛" over bearing housings. Features include scientifically designed air intake . . . dual cooling fans...dynamically balanced rotor... self-aligning, oiless sleeve bearings.

MODEL D-6 (1/100 H. P.)

4-pole, shaded pole induction motor. Free Speed—1735 R.P.M. Locked Rotor Torque—2¼ in. oz.—H.P. at 1400 R.P.M.—1/100; Dimensions: 3⅛" square x 2⅝" over bearing housings. Features include dual cooling fans...dynamically balanced rotor... self-aligning, oiless sleeve bearings.

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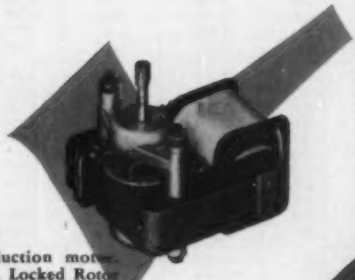
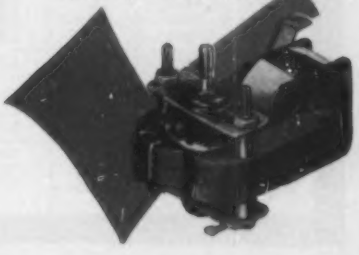


MODEL C-5 (1/300 H. P.)

2-pole, shaded pole induction motor. Free Speed — 3370 R.P.M. Locked Rotor Torque — 0.9 in. oz. — H.P. at 2600 R.P.M.—1/300; Dimensions: 2" wide x 3½" long x 2⅞" high. Features include accurately aligned motor shaft . . . oiless bearings . . . dynamically balanced rotor.



MODEL A-5 (1/250 H. P.)

2-pole, shaded pole induction motor. Free Speed — 3470 R.P.M. Locked Rotor Torque—1.2 in. oz.—H.P. at 2800 R.P.M. —1/250; Dimensions: 2½" wide x 3⅜" long x 2¼" high. Features include novel bearing construction which insures rigid and permanent alignment of motor shaft . . . oiless bearings . . . dynamically balanced rotor.

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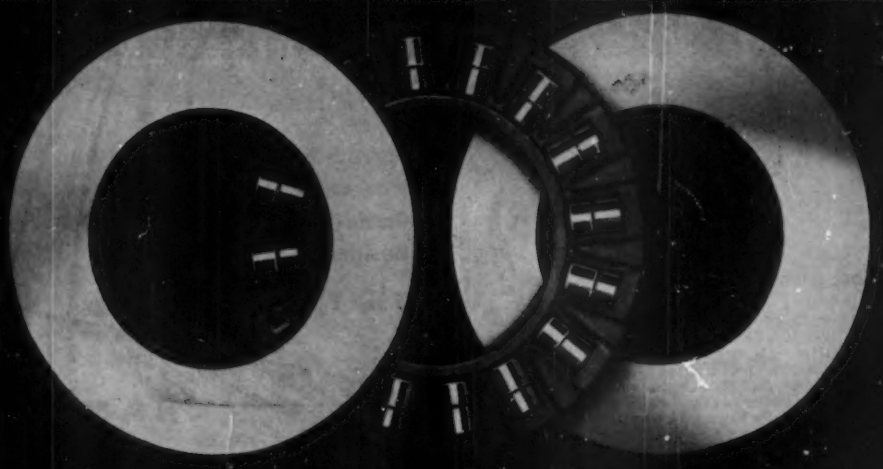

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Bearing No.	Sizes and Dimensions • See Drawing Above						Roller Diam.	R 45° Chamfer	Lbs. †Capacity at 100 R.P.M.
	B_1	B_2	C	D_1	D_2	H			
RT-26	2.002"	2.015"	2.010"	5.968"	6.000"	1.375"	½"	.062"	36,000
RT-27	2.002	2.015	2.010	6.968	7.000	1.375	½	.062	40,300
RT-28	2.002	2.015	2.010	7.968	8.000	1.375	½	.062	65,400
RT-36	3.002	3.015	3.010	5.968	6.000	1.375	½	.062	29,800
RT-37	3.002	3.015	3.010	6.968	7.000	1.375	½	.062	43,600
RT-38	3.002	3.015	3.010	7.968	8.000	1.375	½	.062	55,600
RT-39	3.002	3.015	3.010	8.968	9.000	1.375	½	.062	67,500
RT-47	4.002	4.015	4.010	6.968	7.000	1.750	⅝	.062	34,700
RT-48	4.002	4.015	4.010	7.968	8.000	1.750	⅝	.062	54,600
RT-49	4.002	4.015	4.010	8.968	9.000	1.750	⅝	.062	69,400
RT-410	4.002	4.015	4.010	9.968	10.000	1.750	⅝	.062	89,300
RT-58	5.002	5.015	5.010	7.968	8.000	1.750	⅝	.062	40,300
RT-59	5.002	5.015	5.010	8.968	9.000	1.750	⅝	.062	63,300
RT-510	5.002	5.015	5.010	9.968	10.000	2.000	¾	.125	83,300
RT-511	5.002	5.015	5.010	10.968	11.000	2.000	¾	.125	111,600
RT-512	5.002	5.015	5.010	11.968	12.000	2.000	¾	.125	136,300
RT-69	6.002	6.015	6.010	8.968	9.000	2.000	¾	.125	48,300
RT-610	6.002	6.015	6.010	9.968	10.000	2.000	¾	.125	76,000
RT-611	6.002	6.015	6.010	10.968	11.000	2.000	¾	.125	100,100
RT-612	6.002	6.015	6.010	11.968	12.000	2.000	¾	.125	124,300
RT-710	7.002	7.015	7.010	9.968	10.000	2.000	¾	.125	62,400
RT-711	7.002	7.015	7.010	10.968	11.000	2.000	¾	.125	85,800
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(2) **STEPPING RELAYS**—G. H. Leland, Inc. Dayton 2, Ohio. Bulletin, 4 pp. Explains the applications and construction of a combination solenoid and rotary switch. This combination unit is to be used with radios, coin machines, coaxial switch drives and other remote control problems such as stepping, counting, adding, latching and circuit selecting.

(3) **IRON AND STEEL METALLURGY**—Hunt-Spiller Mfg. Corp., 884 Dorchester Ave., South Boston 27, Mass. Booklet, 24 pp. Gives a metallurgical review of all the standard iron and steel castings made by the company. Includes notes on chemical and physical properties, and typical uses.

(4) **GRAY IRON SPECIFICATIONS**—Gray Iron Founders' Society, Inc., 210 National City, E. 6th Bldg., Cleveland 14, Ohio. Folder, 4 pp. Contains a resume of the provisions of 14 separate sets of gray iron specifications drawn up by recognized specification-writing bodies.

(5) **STAINLESS STEEL FILTERS**—Micro Metallic Corp., 193 Bradford St., Brooklyn, N. Y. Bulletin, 8 pp pictures, drawings, and text explain the construction and use of "Surfamax" porous stainless steel filter elements. The accordion-shaped filters are available in six pore openings, ranging from 6 to 185 Microns.

(6) **ROLLER CHAINS**—Chain Belt Co., Baldwin-Duckworth Div., 1600 W. Bruce St., Milwaukee 4, Wis. Bulletin 49-3, 24 pp. Shows a number of unusual applications of roller chains, and explains the engineering principles of each application. Simplified working drawings explain complex installations.

(7) **CORROSION-RESISTANT ALLOYS**—Union Carbide and Carbon Corp., Haynes Stellite Div., 30 E. 42nd St. New York 17, N. Y. Booklet, 40 pp. Tells the story of the four Hastelloy alloys—what they are, how they can be fabricated, and how they can be used to combat severe corrosion.

(8) **SHAFT DESIGN**—DeLaval Steam Turbine Co., Trenton 2, N. J. Bulletin C-7, 26 pp. Contains formulas, curves, and tables to assist designers in determining proportions, stresses, combined torsional and bending loads, etc., in round, square, hollow, keyway, and stepped shafts. A fact-filled data book.

(9) **ELECTROSTATIC PRECIPITATION**—General Electric Co., Apparatus Dept., Schenectady 5, N. Y. Bulletin GEA-5312, 16 pp. Explains how electrostatic precipitation works, gives case histories, and describes equipment needed. The process is used for painting, deposition, orientation, and separation.

(10) **BERYLLIUM-COPPER STRIP, ROD, BAR, WIRE**—The Beryllium Corp., Reading, Pa. Bulletins 13 and 13A, 8 pp. each. Gives the complete procedure for specifying and ordering beryllium-copper strip, rod, bar, and wire stock. Sizes and properties are included.

(11) **SELECTING SMALL MOTORS**—Westinghouse Electric Corp., 306 Fourth Ave., Box 1017, Pittsburgh 30, Pa. Bulletin 2-3075-C, 6 pp. A large illustrated chart shows hp ranges, speed characteristics, torques, reversibility, bearings, mountings, and applications of small motors. The folder lists the factors to be considered in selecting the right motor for the application.

(12) **STAINLESS ALLOY CASTINGS**—The Cooper Alloy Foundry Co., Hillside, N. J. Reference chart, 6 pp. Handy chart lists physical properties of stainless, corrosion, and heat resistant alloy castings. Of special interest is a complete list of applications for each alloy.

(13) **SOCKET SCREWS**—Parker-Kalon Corp., 200 Varick St., New York 14, N. Y. Catalog 496-A, 16 pp. Photos and drawings show styles and shapes of various cold-forged socket screws available. Tabulated data gives sizes, thread types, and classes of fit available. Set screws, cap screws, stripper bolts, and hex keys are listed.

(14) **MILLIAMMETER**—The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, Ohio. Bulletin 4 pp. Describes the Model 209A Electronic Volt Ohm Capacity Milliammeter, which measures resistance as low as 1/10 ohm, and has peak-to-peak voltage measurement.

(15) **INSTRUMENT RENTAL SERVICE**—InstruRental Co., 411 Albee Bldg., Washington 5, D. C. Catalog, 14 pp. Describes a complete line of instruments, such as voltmeters, recording wattmeters, ammeters, etc., which are available on a rental basis.

(16) **ROTARY SWITCHES** — Electro Switch Corp., 147 King Ave., Weymouth 88, Mass. Catalog 1950-P, 12 pp. Describes type "P" rotary switches, which are multipole, snap switches for the control and transfer of electric circuits. Cut-away views and other pictorial information explain construction and give switch selection details.

(17) **BRONZE BEARINGS** — Johnson Bronze Co., New Castle, Pa. Catalog L-5, 16 pp. A condensed listing of stock sizes of bronze bearings made by powder metallurgy. Line drawings show construction of typical bearings. A price list is included.

(18) **BALL BEARINGS**—Nice Ball Bearing Co., 46th and Hunting Park Ave., Philadelphia 40, Pa. Catalog 146, 48 pp. Cut-away views and drawings show construction of typical bearings. Complete tabulated information gives dimensions, capacities, speeds, prices, and other necessary information.

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(22) **FREE-CUTTING STEEL**—Jones & Laughlin Steel Corp., Pittsburgh 30, Pa. Booklet, 8 pp. Features type "E" free-cutting steel, which is a new bessemer screw stock with exteremely high machinability. Booklet describes typical case histories and recommends applications.

(23) **IMPULSE TIMER**—Zenith Electric Co., 152 W. Walton St., Chicago 10, Ill. Bulletin, 4 pp. Describes Model RT impulse timer. Timer provides impulse circuit for elevator starting, pilot circuit, production line control, laboratory testing, and other such applications.

(24) **GEARMOTORS**—Foote Bros. Gear and Machine Corp., 4545 S. Western Blvd., Chicago 9, Ill. Bulletin, 16 pp. Presents a line of gearmotors available in 17 sizes, in single, double, and triple reductions. Output speeds vary from 780 to 7.5 rpm, with a capacity of from 1 to 75 hp. All types of motor enclosures are available.

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(27) **VARIABLE SPEED CONTROL**—Reeves Pulley Co., Columbus, Ind. Catalog M-492, 40 pp. Describes the Motodrive, which combines a standard electric motor with a speed control mechanism, and where required, a helical gear speed reducer in one compact unit. Gives sizes, styles, speeds, and other data.

(28) **PUMPING UNIT**—Sundstrand Pump Div., Sundstrand Machine Tool Co., Rockford, Ill. Bulletin 189, 4 pp. Presents the "Rota-Roll", a combination pump, relief valve, and strainer. Unit is for engine lubrication, compression bearing lubrication, small cylinder actuation, and small capacity oil transfer.

(29) **PRESSURE SWITCH**—Sorensg Mfg. Corp., 9555 Eden Ave., Schiller Park, Ill. Bulletin, 4 pp. Describes pressure switches for fixed and variable level control of moderate liquid heads. Bulletin covers design requirements, operating characteristics, calibration, and applications. Dimensional drawings are included.

(30) **SPROCKETS AND CHAINS**—Cullman Wheel Co., 1344 Altgeld St., Chicago 14, Ill. Catalog 50, 52 pp. Covers roller chains, bronze chain, chain parts, chain conversion tables, and standard components, as well as hub sprockets and single and multiple sprockets with from ¼ to 1 in. pitch. Gives installation data and other full information on sprockets and chains.

(31) **SPEED REDUCERS**—Dodge Mfg. Corp., Mishawaka, Ind., Bulletin A-470, 16 pp. Presents the new "torque-arm" speed reducer, which is made in six sizes with capacities up to 25 hp. Output speeds vary from 13 to 193 rpm. The unit is v-belt driven, and mounts directly on the driven shaft.

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(35) **SPEED REDUCERS**—D. O. James Gear Mfg. Co., 1140 W. Monroe St., Chicago 7, Ill. Catalog 46-B, 48 pp. Covers continuous tooth herringbone gear reduction gears with a ratio range from 7:1 to 460:1 with capacities up to 1,500 hp. Gives rating tables and a simplified method of selection.

(36) **WELDED FABRICATION** — The American Welding & Mfg. Co., Warren, Ohio. Bulletin, 20 pp. Describes a complete welding service. The company fabricates components parts for other manufacturers.

(37) **VARIABLE SPEED TRANSMISSION**—Reeves Pulley Co., Columbus, Ind. Catalog T-497, 52 pp. Dimensional drawings and a great deal of tabulated information describe a line of variable speed transmissions and suggest applications. Gives operating principles. Installation data, weight tables, and types of controls.

(38) **CHROMIUM CHEMICALS** — Diamond Alkali Co., 300 Union Commerce Bldg., Cleveland 14, Ohio. Handbook, 32 pp. Presents complete data on bichromate of soda, sodium chromate, and bichromate of potash. Discusses applications and gives full chemical data on these commercial chemicals.

(39) **GEAR-MOTORS**—Jarette Mfg. Co., 556 W. Monroe St., Chicago 6, Ill. Bulletin 2-100, 4 pp. Pictures and descriptions of 18 types of gear-motors made in 30 sizes. Units have speeds from 0.05 to 450 rpm and from 1/20 to 7½ hp ratings. Motor types are: direct current, polyphase, split phase, and capacitor.

(40) **MATERIALS USED IN FARM IMPLEMENTS** — The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y. Bulletin, 32 pp. Discusses nickel-containing materials in tractors and farm implements. Many charts, tables, graphs, and pictures illustrate the text.

(41) **LOCKNUTS AND LOCKWASHERS** —Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill. Folder 2343, 4 pp. Announces a new line of bearing positioning locknuts and lockwashers that are specially designed for effectively locking ball and roller bearings in correct position on shafts from 5/16 to 7 11/16 in. in diameter.

(42) **LOCKNUTS**—The Palnut Co., 61 Cordier St., Irvington 11, N. J. Bulletin, 4 pp. Gives two interesting case histories, and explains the locking principle and application of the company's locknut.

(43) **CAST SPROCKETS**—Chain Belt Co., 1600 W. Bruce St., Milwaukee 4, Wis. Bulletin 43-30, 16 pp. Describes stock size cast sprockets for use with drive and conveyor chains. Dimensions, specifications, list prices, sprocket style and other data are given. Rules for selection, alignment, and care of sprockets are given.

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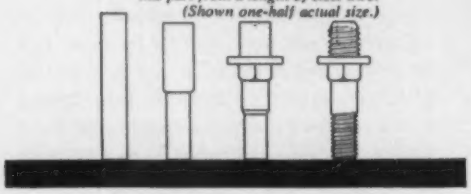

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Rigidframe

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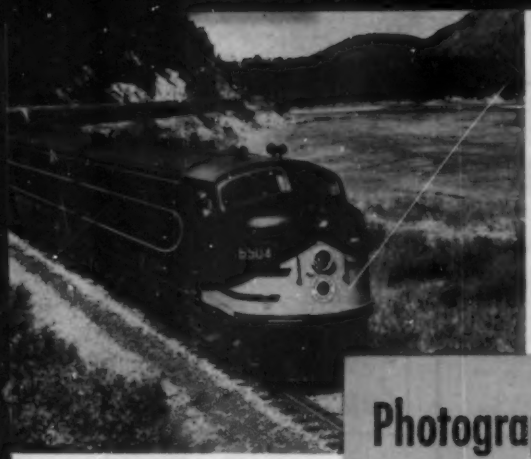

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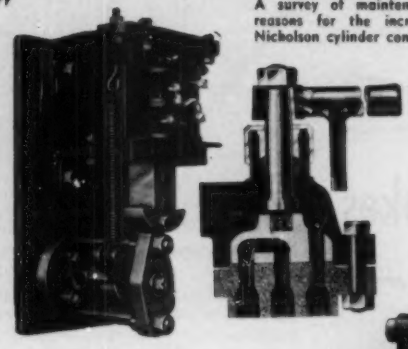

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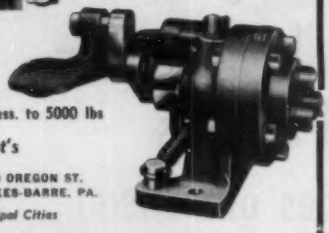

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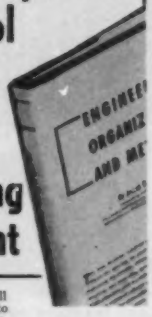

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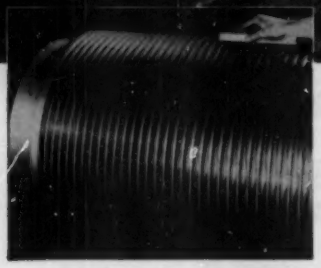

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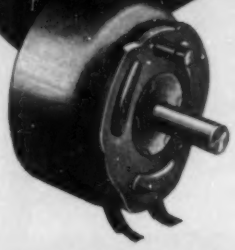

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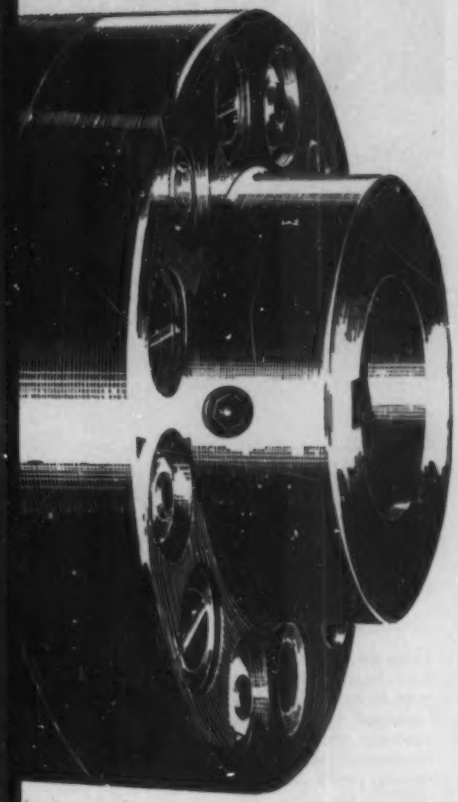

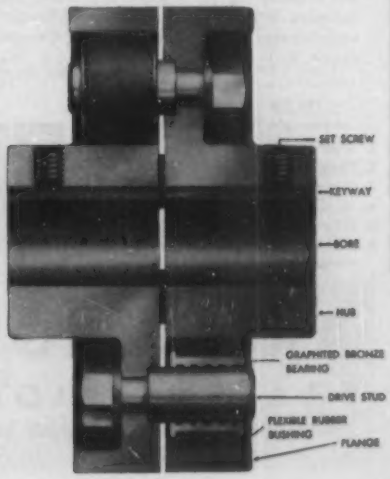

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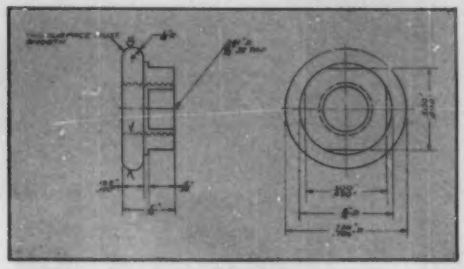

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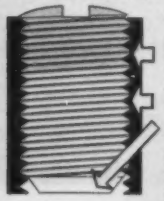

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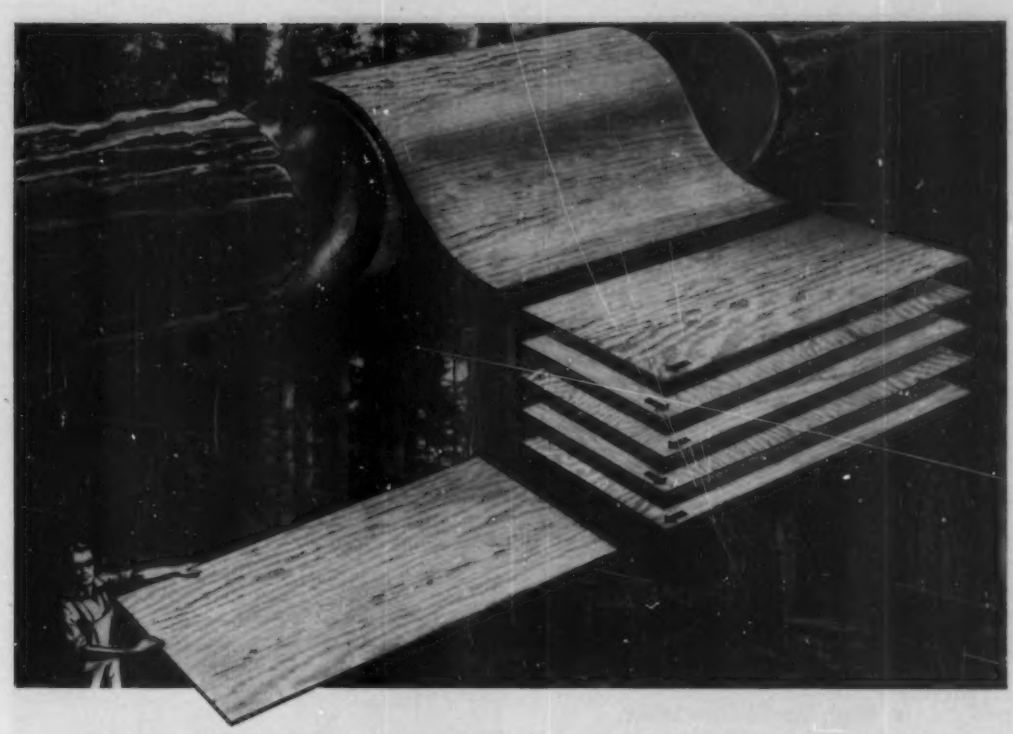

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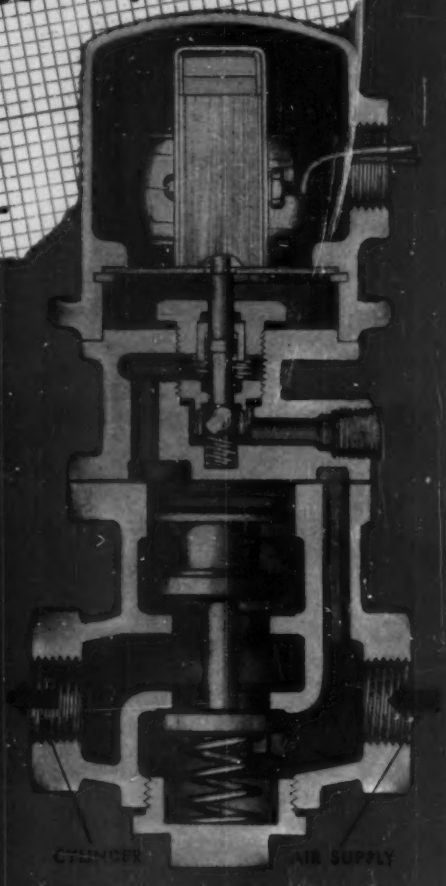

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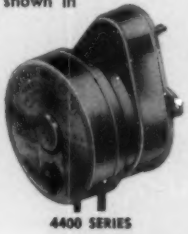

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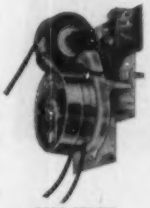

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Fluid pressure: 1000 PSI

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Leakage allowance: none

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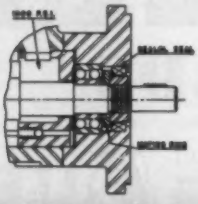

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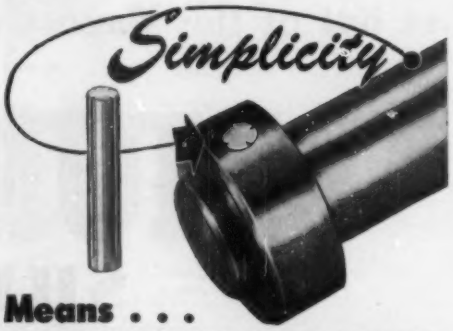

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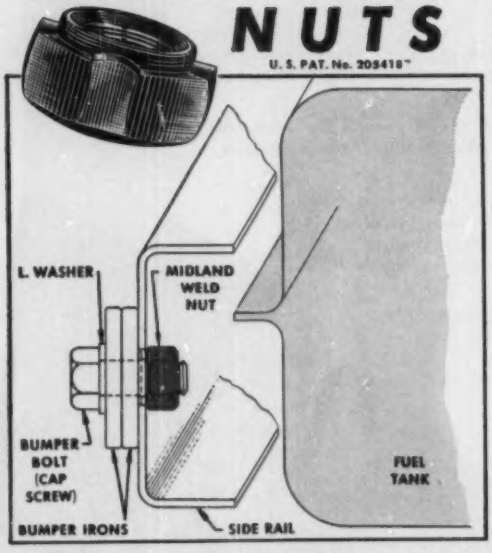

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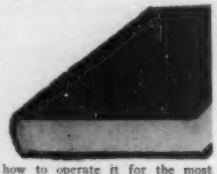

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9. Internal Organization of the Laboratory
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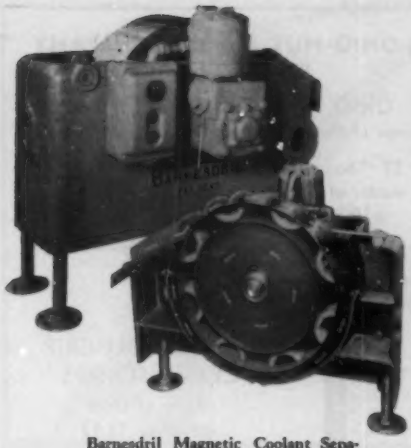

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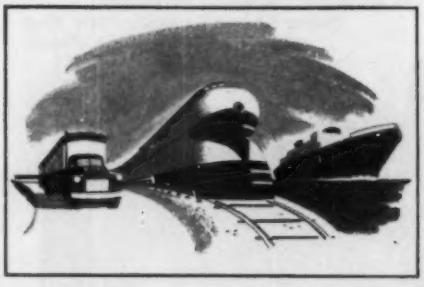

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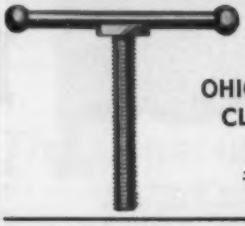

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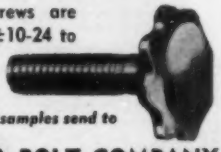

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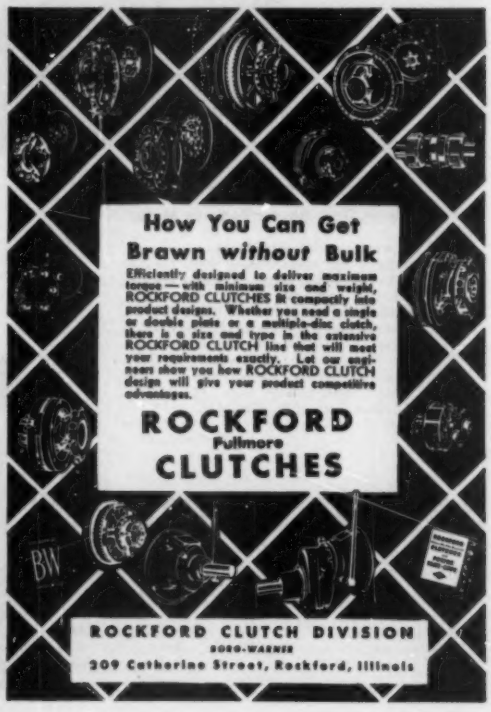

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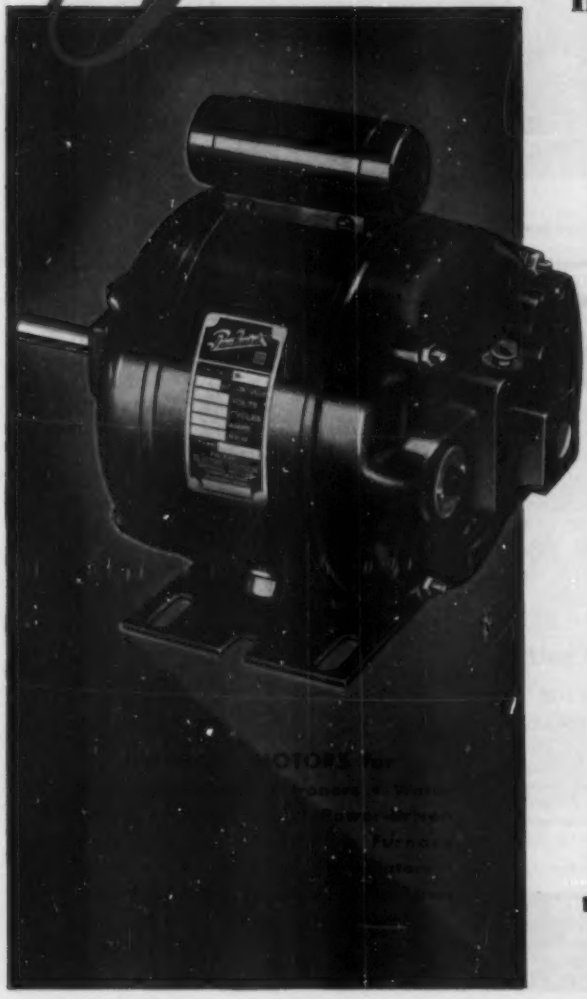

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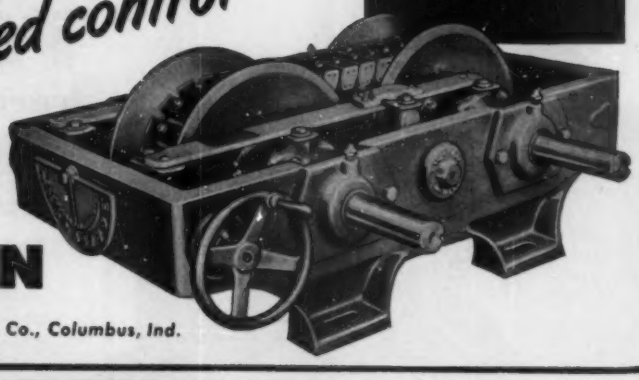

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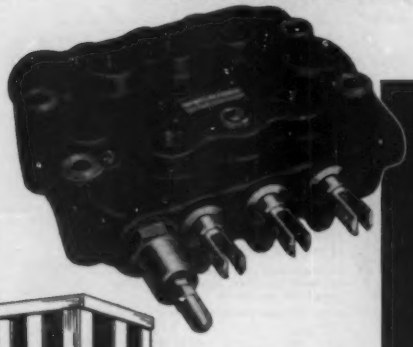

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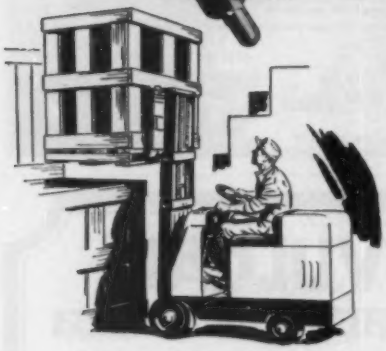
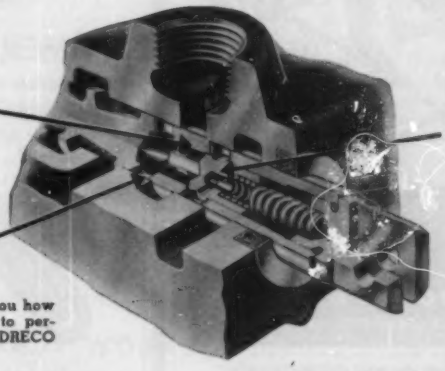
HOLLOW-PLUNGER* VALVES

— for smooth and accurate control of raising, tilting and accessory operations.

HYDRECO Hollow-Plunger control valves build in the fast and safe control so necessary to proper lift truck operation. Accurate throttling characteristics, inherent in HYDRECO valves, cut out lost motion in picking up and stacking. Built-in check valves of the Hollow-Plunger design entirely eliminate momentary load drops and jerky operations. There are no dead spots in HYDRECO valve operation to create pressure peaks, damaging to the hydraulic system.



HYDRECO EQUIPPED TRUCKS CUT OPERATING COSTS FOR THEIR OWNERS.



Patented hollow plunger with no dead spots to create pressure peaks.

Circular ports are staggered in the plunger for accurate throttling.

Check valve assembly prevents pressure drop in the cylinder while pressure port is opening.

Let HYDRECO engineers show you how your equipment can be made to perform faster and safer with HYDRECO Hollow-Plunger control valves.

*Hollow-Plunger protected by existing U. S. and Foreign Patents as well as patents applied for.

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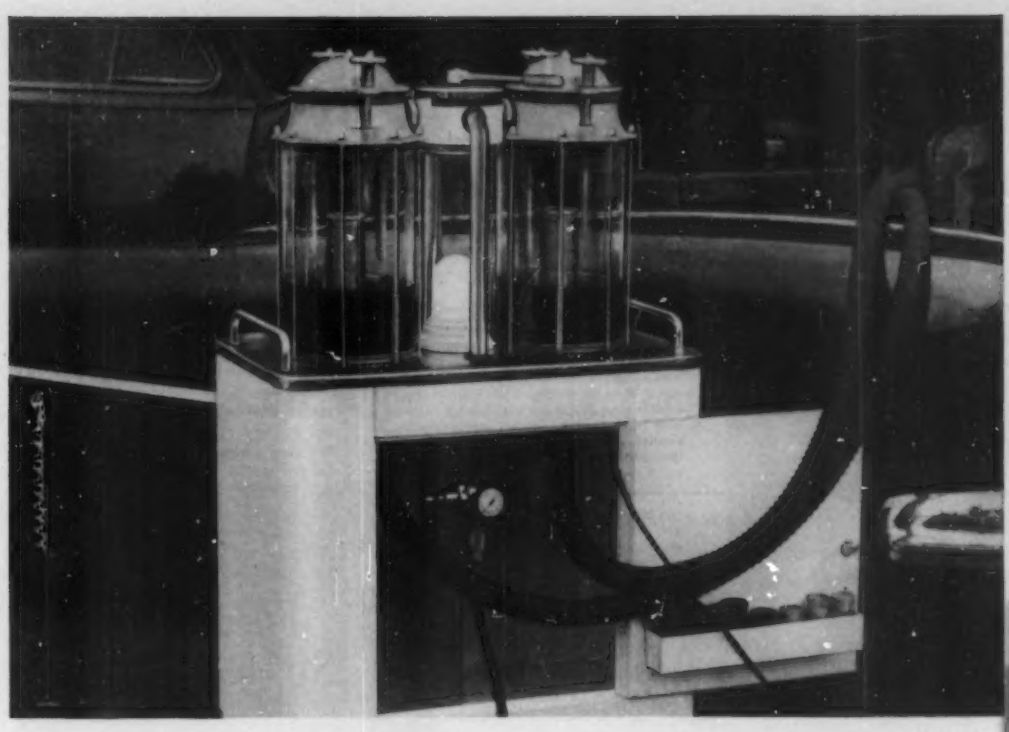

PYREX BRAND Cylinders Help The Engineers Solve A Merchandising Problem

Here is another case where glass by Corning helped an engineering department lick a merchandising problem. It points up once again how versatile glass is as an engineering material.

The "Pressure-Purger," made by Choldun Manufacturing Co., cleans automobile cooling systems by forcing a preheated chemical solution through the radiator and motor block water jackets under pressure. A reversing action loosens, dissolves and filters out rust, scale, grease and grime . . . *before your eyes!* That didn't happen, however, until Choldun's engineers got together with Corning.

Visibility was the key factor in merchandising the Pressure-Purger for with it garage men could *show* customers exactly what was happening. Glass was the obvious answer. But this glass also had to possess high physical strength, as well as extreme thermal and corrosion resistance. It had to meet close mechanical tolerances. It must be reasonably priced.

All of these requirements are inherent in PYREX brand glassware. Corning-know-how makes it available in volume at low cost. Result: a product that helps to sell itself by demonstration through glass. If you are a product or design engineer, check the possibilities of using glass by Corning before the blue print stage. Send for "Properties of Selected Commercial Glasses" and "Design and Manufacture of Commercial Glassware."

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EXPERIENCE IS YOUR ASSURANCE OF QUALITY WORK AT A LOW COST

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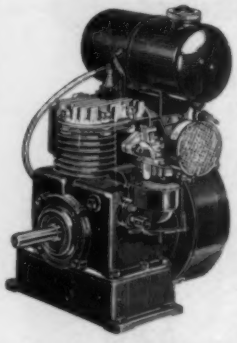

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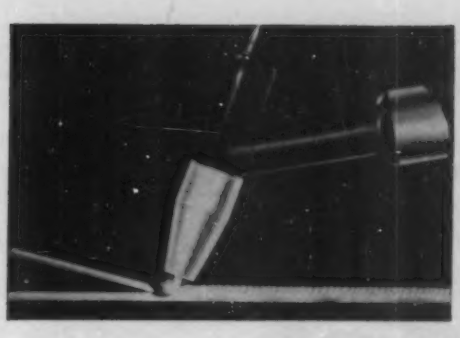
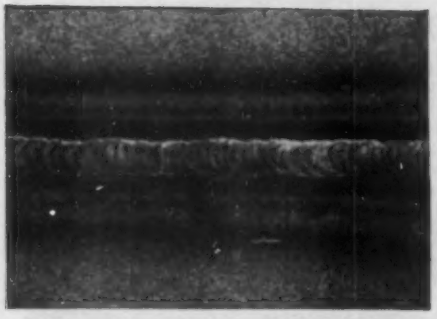
Weld Sheet Steel with the HELIARC torch

Trade-Mark



and wipe out one complete operation



AS WELDED — *This photograph, unretouched and natural size, shows that* HELIARC *welds in sheet steel are clean and uniform.*

There is no spatter or flux, so you save cleaning costs when you switch to the HELIARC process for welding sheet steel. And you keep the advantages of high speed, and minimum distortion that are characteristic of arc welding. Any manual arc or gas welding operator finds welding with a HELIARC torch easy to master.

Porosity-free welds in killed low-carbon steel up to ⅛ in. thick can be made with this process. In non-killed grades, welds are as nearly gas free as can be produced by any welding process. Argon-shielding prevents pick-up of atmospheric gases. No argon is dissolved in the weld.

Joints welded with the HELIARC torch will not show under paint, lacquer, or even vitreous enamel finish. It takes only a light grinding to remove the low, smooth ripple and make the bead flush with the surface.

Get more information on this fast, clean, welding process from any LINDE office. Let us show you how it can improve your product and cut your costs. Just fill in the coupon.

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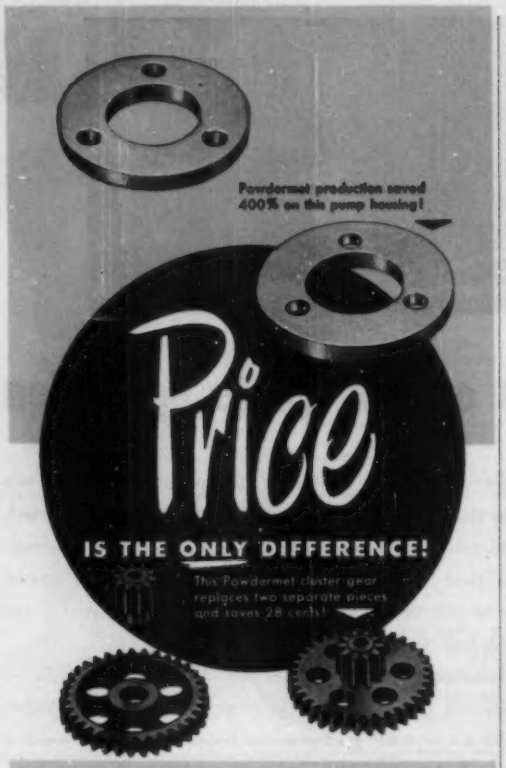
Gentlemen: We would like more information on welding sheet steel with the HELIARC torch. We manufacture ..... (Product)
from ..... (Metal) of ..... (Thickness)
We are ☐ (are not ☐) now using inert gas-shielded welding

Name.....Position.....

Company.....

City.....State.....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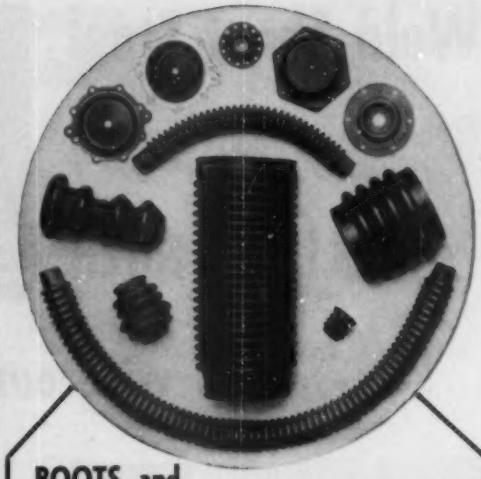

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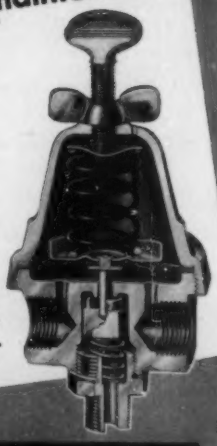

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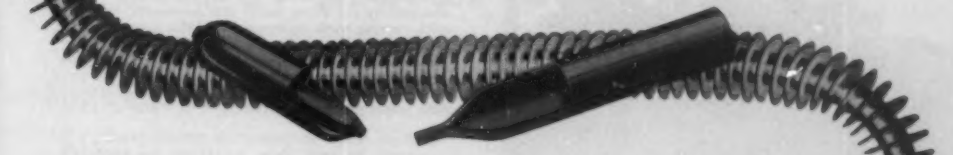

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SEND FOR our new brochure that gives you more complete information about the Wolverine Spun End Process and how it can help bring you reductions in production costs. No obligation in asking for it on your company stationery.

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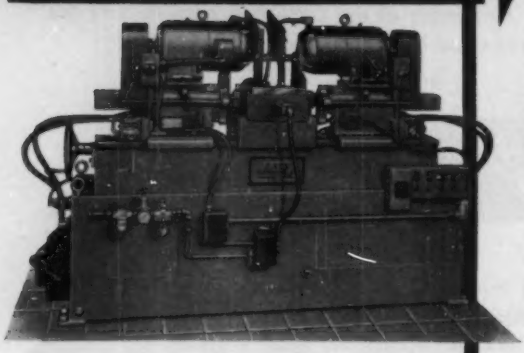

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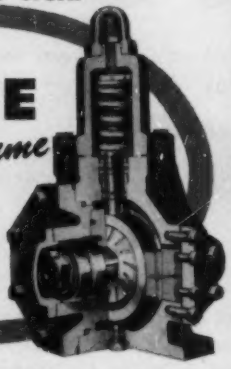

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SLEEVE BEARING DATA

Bearing TYPES

JOHNSON BRONZE
SLEEVE BEARING DATA

Sheet Metal Bearings-3

Steel-Back Babbitt-Lined Bearings

THIS TYPE of Sleeve Bearing is usually referred to as "laminated". This because two separate metals are firmly bonded together. In the automotive industry, the largest user, they are sometimes referred to as "Slip-in" bearings.

The first step in the manufacturing process is the coating of the steel strip—S.A.E. 1010—with either tin-base or lead-base babbitt . . . as the application may require. This is a continuous process with exact temperature control and necessary precautions to prevent oxidation. Extreme care must be exercised in this operation in order to secure a perfect, durable and lasting bond of the two metals. Next, the strip is brought to the desired thickness. The balance of the manufacturing procedure is essentially the same as in other types of sheet metal bearings . . . stamping, forming and finishing to precise size. Steel and babbitt bearings are available in a wide range of sizes, plain or flanged, half bearings or cylindrical. Oil grooves, slots or holes can be incorporated during stamping operation.

Several standard thicknesses of steel are used, depending on the nature of the application. For example: .036, .050, .060, .070, .080, .090 and .100. In general applications the thickness of the babbitt will run from .015 to .020. While on precision-type bearings it is held to .002 to .005.

The selection of the babbitt depends quite naturally on the bearing application. Lead-base babbitt is much more economical than tin-base and in certain alloys will provide a higher load carrying capacity. While tin-base is more expensive it has better corrosion resistant properties and a higher fatigue strength. Both materials have performed very well in automotive, diesel and electric motor applications, with a slight preference for tin-base babbitt in main and connecting rod bearings.

While steel-backed babbitt-lined bearings are best suited for light to moderate loads with high speed, there is a definite relation between the thickness of the babbitt and the

load carrying capacity of the bearing. A babbitt thickness of .020 has a generally rated load capacity of 1500 pounds per square inch whereas by holding the babbitt to .002 to .007 increases the capacity up to 2000 pounds per square inch. This results in longer bearing life.

When babbitt-lined bearings are used within the range of their load capacity they are generally considered the best bearings available. They can be used with steel shafts of practically any hardness. It must be remembered, however, that as the hardness of the shaft increases, the resistance to wear increases.

The method of installing steel and babbitt is practically the same as bronze and steel or bronze sheet metal. We recommend that they be

line reamed or bored in assembly. Burnishing should be avoided if possible.

Main bearings are usually produced on specially designed equipment to keep within a tolerance of .00025 and .0005. This accuracy permits any two halves to make one complete bearing, thus simplifying installation.

Some of the most desirable qualities of steel and babbitt bearings are:

1. Good wettability with lubricants.
2. High corrosion resistance to most oils at operating temperatures.
3. High embeddability.
4. Good conformability.
5. Work well with soft shafts.

•

Engineering Service

Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

This bearing data sheet is but one of a series. You can get the complete set by writing to—

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SLEEVE BEARING HEADQUARTERS
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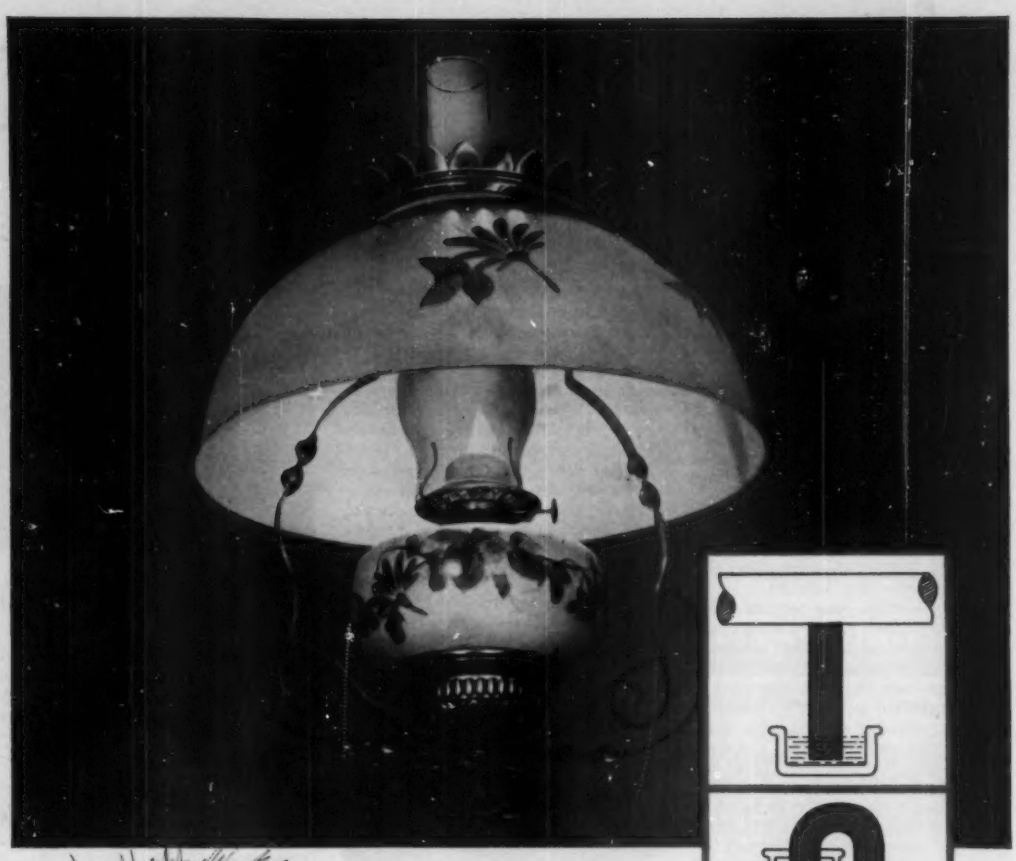

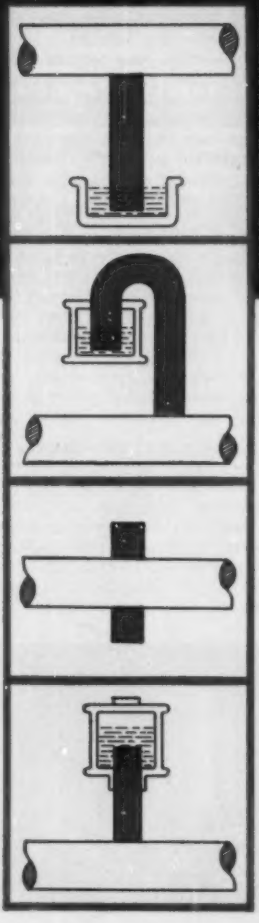

LIGHT from a lamp

Anyone who has ever used or seen a kerosene lamp or lantern knows how steady and clear the flame is, once the wick is correctly adjusted. The reason for this steady, smokeless and wasteless flame is that the wick feeds exactly the amount of oil required. Capillary action does the trick, plus correct wick type and adjustment.

Felt wicks can and do serve just as perfectly in lubrication. When correctly specified to meet the requirements of lubricant viscosity and delivery rate, they provide an accurately-metered quantity of oil to friction surfaces. It is not unusual for wick-lubricated bearings to serve without attention except at major overhauls; in other cases, re-filling of reservoirs at long intervals may be required. Felt wicks can be designed to deliver from a fraction of a drop per day, to many drops per hour; thus actual operating needs can be met. The basic source of wick lubrication technical data is American Felt Company's Data Sheet No. 6, "Wicks and Lubrication." Write for it today.

American Felt Company

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50 amp — 300* v
100 amp — 300 v

*150 volts between taps

Compact-Dependable

Equipment manufacturers know that when they require high-current, non-shorting rotary tap switches, they can usually find the right type and size in the Ohmite line. Ohmite high-current tap switches are particularly designed for a-c use. Illustrated are five sizes of high-amperage, multi-point selectors. They are extremely compact, providing up to 12 tap terminals. Capacities range from 10 to 100 amperes a-c. In addition to the models shown, Ohmite tap switches are available in open-type models, for both shorting and non-shorting applications. Ohmite is also prepared to supply open-type tap switches with special features—such as special angles between taps, and capacities up to 25 contact points. All Ohmite switches can be mounted in tandem for multiple-pole operation.

Be Right with —

OHMITE

25th Anniversary

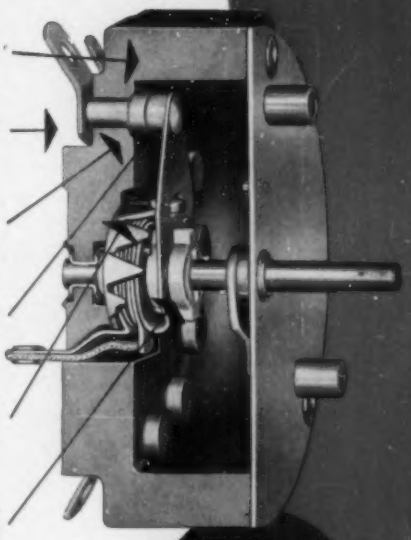
Reg. U.S. Pat. Off.

RHEOSTATS • RESISTORS • TAP SWITCHES

OHMITE *High-Current, Rotary* TAP SWITCHES

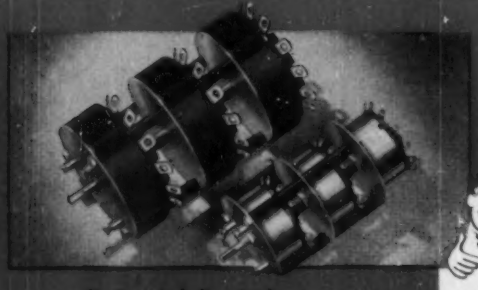
—PREFERRED THROUGHOUT INDUSTRY

1. **CERAMIC CONSTRUCTION** provides perfect insulation, unaffected by arcing. Contacts and mechanism are entirely enclosed and protected (except for Model 111).
2. **EXTREMELY COMPACT,** yet have many high-current taps, perfectly insulated. Terminals are convenient for wiring. Back-of-panel mounting.
3. **SILVER-TO-SILVER CONTACTS,** for high electrical conductivity. Have low surface resistance, and eliminate contact maintenance.
4. **SELF-CLEANING ROTOR CONTACT.** Slightly rounded, assuring perfect seating and producing slight rubbing motion with every operation.
5. **"SLOW-BREAK" MECHANISM,** incorporating a positive cam-and-roller. Provides "slow-break, quick-make" action, particularly suited to alternating current. Minimizes sparking, extends contact life.
6. **"DEAD" SWITCH SHAFT.** Completely insulated from the load by a high-strength driving hub which will withstand a 2000-volt test.



5 SIZES
10 to 100 Amp.
A-C

AVAILABLE IN TANDEM MOUNTINGS



Have many applications, including simultaneous control of separate circuits. Extended shafts, with universal coupling for single-knob control of two or three switches.

Write on Company Letterhead for Catalog and Engineering Manual No. 40.

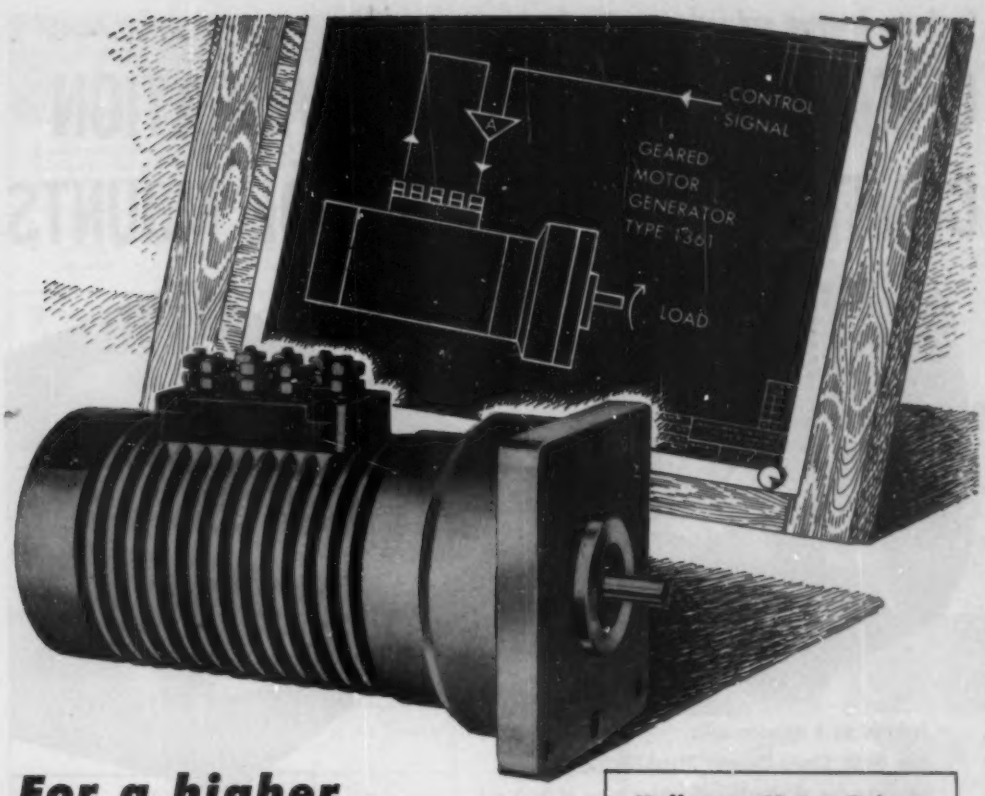
OHMITE MFG. CO.
4835 Flournoy Street
Chicago 44, Ill.

25th Anniversary
1925-1950

OHMITE

Reg. U.S. Pat. Off.

RHEOSTATS • RESISTORS
TAP SWITCHES



For a higher order of PRECISION in control

The characteristics of Kollsman miniature Motor-Driven Induction Generators suggest many remote indication and control applications. These light, space-saving units — precision-engineered for extreme sensitivity — combine motors of high torque/inertia ratio with generators offering *linear voltage vs. speed* ratios over a wide range.

These Motor-Driven Induction Generators are representative of a complete line of small Kollsman special-purpose AC motors. If those available do not meet the requirements of your particular instrumentation or control problem, Kollsman laboratories are staffed and equipped to develop a unit to your specifications. For further information, write: Kollsman Instrument Division, Square D Company, 80-56 45th Avenue, Elmhurst, N. Y.

Kollsman Motor-Driven Induction Generators

Motor characteristics: Maximum torque at stall — smooth-running (will not "cog"), fast-reversing — operate from 2-phase source, or from single-phase source with phase-shifting condenser.

Generator characteristics: Low residual voltage — output/residual voltage ratio of 100:1 in some models — residual voltage "spread" as low as 2 millivolts — available with built-in voltage temperature compensating network — constant frequency output — amplitude directly proportional to speed.

Unit characteristics: Both rotors mounted on same shaft, assuring positive alignment — geared models, with ratios between 5:1 and 75,000:1, designed to safely transmit a maximum torque of 25 oz./in. — backlash held to a minimum.

KOLLSMAN INSTRUMENT DIVISION

SQUARE D COMPANY

ELMHURST, NEW YORK — GLENDALE, CALIFORNIA

For better damping and easier installation . . .

ONE-CYLINDER DIESEL'S VIBRATION CONTROLLED WITH ISOMODE* MOUNTS

ONAN 2500 watt Diesel Electric Plant, Model 205DSP. Cutaway section shows the Isomode shock mounts.

Isolated on 4 Isomode units, this ONAN Single Cylinder Diesel-Electric Set needs no ton of vibration-absorbing mass at its base!

Single-cylinder Diesels, due to large unbalanced inertia forces, present a tough problem in vibration. In fact, without suitable isolation, such a power plant usually requires a massive foundation to control the destructive vibrations. Faced with this problem, Onan engineers rigorously tested a number of vibration isolators in a search for the right answer.

And they found it, to their complete satisfaction—in Isomode mounts. Not only did these units provide outstanding damping of motion, but they allowed easy installation on the generator set as well! The four Isomode isolators permit this electric plant to be bolted directly to the floor. Moreover, because they're uniformly flexible in all directions, these mounts also reduce strains on engine parts.

This typical case once again demonstrates the advantages of using the mounts with *equal spring rates in all directions*—MB mounts. More and more designers are discovering how they give improved isolation, last longer—and often simplify mounting bracket design and installation. In these units you may find the solution to your own problem, too. Write us. Our engineers will gladly go over your requirements with you.

*Trade Mark Reg. U.S. Pat. Off.

THE ADVANTAGES OF designing with ISOMODE MOUNTS

- ✓ *They absorb vibration equally well in all directions* — vertical, as well as troublesome horizontal and rocking motions.
- ✓ *Non-directional* — can be mounted at any angle, in any direction, simplifying design problems.
- ✓ *High load capacity* in compact size — saving space, weight.
- ✓ *Large rubber volume* for softness — yet perfectly stable and self-snubbing.

SEND FOR THIS BULLETIN which gives details on a number of products that can help you with your vibration problems. Write for bulletin No. 410-J6.

THE MB MANUFACTURING COMPANY, INC.
1060 State Street, New Haven 11, Conn.

PRODUCTS AND EQUIPMENT TO CONTROL VIBRATION . . . TO DETECT IT . . . TO REPRODUCE IT

These Features Save You Money	For These Reasons	It's a Worthington—
1 Two-piece QD sheave—rim and hub separate	Mount light hub first, then slide heavier rim on tapered hub	EXCLUSIVE
2 Choice of one or two-piece assembly	Mount hub and rim separately, or loosely assemble hub on rim and slide on shaft together	EXCLUSIVE
3 Split hub	Easy to mount, even on oversized shaft	ORIGINAL
4 Clamp screw in hub	Holds hub in position on shaft while setting or removing rim	EXCLUSIVE
5 Taper-mated hub and rim	Mount easily in any position—no keyway between taper surfaces	ORIGINAL
6 Large, long pull-up bolts	Hold better and more uniformly	EXCLUSIVE
7 Friction cone grip	Tightening rim on hub gives positive press fit on shaft	ORIGINAL
8 Shaft key lock (set screw over keyway)	Prevents key from drifting	EXCLUSIVE
9 Quickly-detachable (QD)	Pull-up bolts used as jack screws to remove sheave rim	ORIGINAL
10 Interchangeable rims	Hubs for every bore—lower inventory cost	ORIGINAL
11 No realignment problem	Clamped hub holds shaft position—new rim tightens up in exact alignment	EXCLUSIVE
12 Choice of "A", "B", "C" and "D" grooves	"Tailor-made" grooves give proper belt "ride-out" for maximum life efficiency	ORIGINAL
13 I-beam spokes on driven sheave	Stronger—capable of carrying heavier load with less weight	EXCLUSIVE
14 Offset design of sheave	Reduces over-hung loads—increases bearing life	ORIGINAL
15 Worthington-Goodyear V-belts	Load-carrying cords in neutral axis reduce internal friction—each belt carries its share of drive load	ORIGINAL

How Does Your Drive Rate on the V-drive Scoreboard?

Here are 15 money-saving features of the most efficient V-belt drive. Only Worthington Multi-V-Drives give you all 15!

WORTHINGTON QD SHEAVE
—ORIGINAL TAPERED CONE-GRIP SHEAVE

Complete Range of Stock Sizes—Prompt Shipment. 853 listed stock sizes in "A", "B", "C" and "D" sections, fhp to 200 hp . . . 332 listed stock sizes of EC Cord V-belts. *Send coupon for latest Worthington QD Sheave bulletin.*

WORTHINGTON

ORIGINATORS OF THE QD SHEAVE
WORTHINGTON PUMP AND MACHINERY CORPORATION
MULTI-V-DRIVE SALES DIVISION
Buffalo, N. Y. · General Offices, Harrison, New Jersey
POWER TRANSMISSION: sheaves, V-belts, variable speed drives
PUMPS: centrifugal, power, rotary, steam
AIR COMPRESSORS: water-cooled, air-cooled

The Good Right Hand of Industry

Worthington Pump and Machinery Corporation
Multi-V-Drive Sales Division, Dept. PO-1
Buffalo, N. Y.

Send latest bulletin of Worthington Multi-V-Drives.

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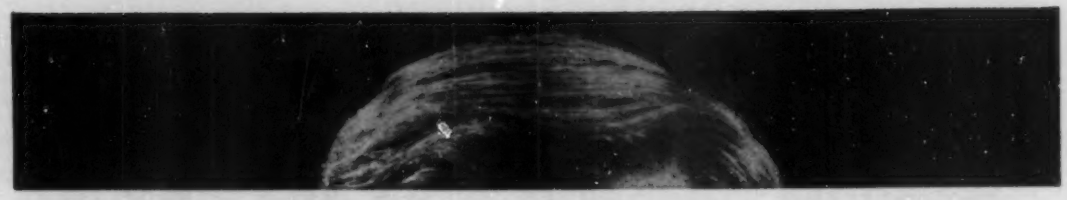
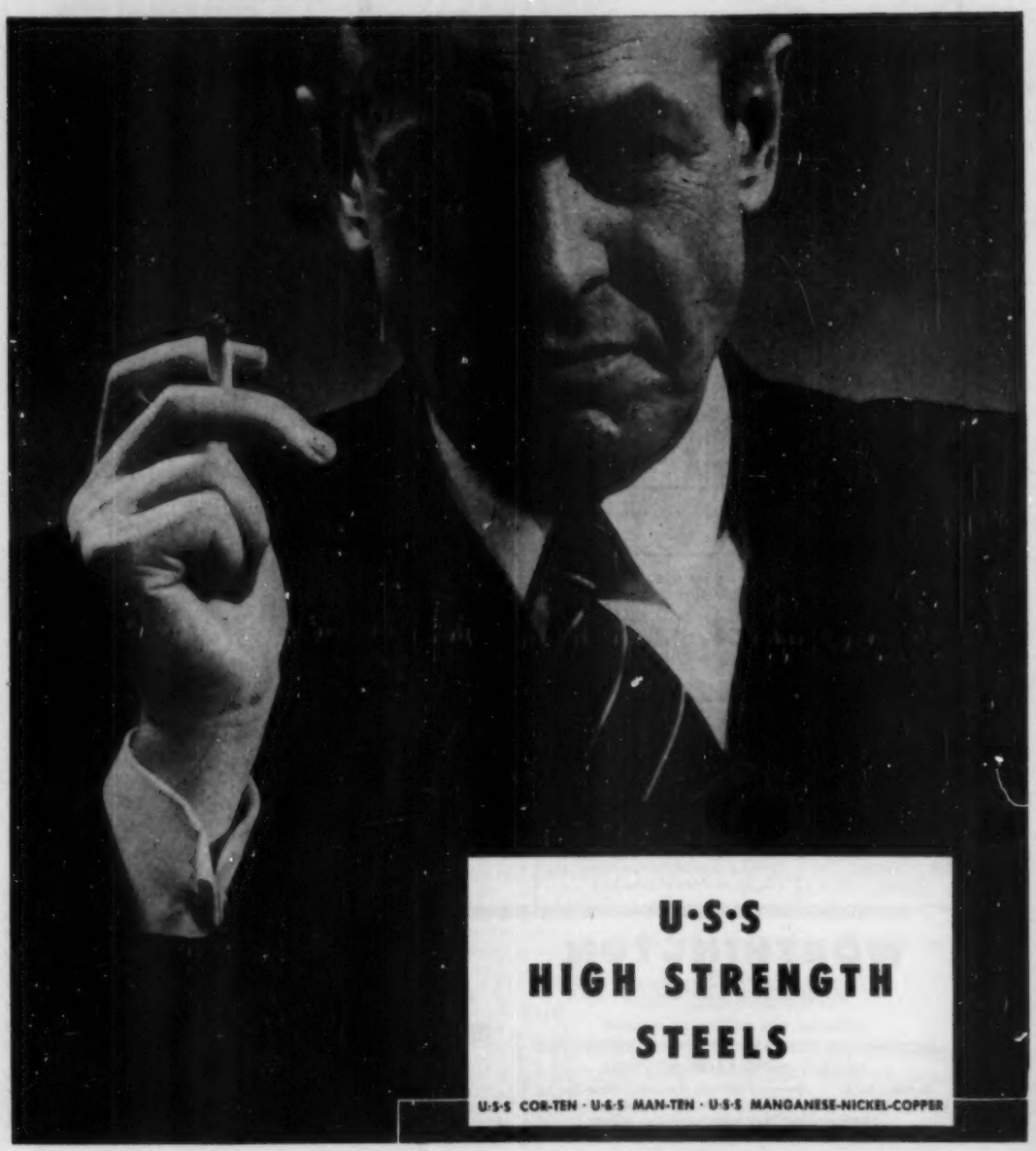
CITY..... ZONE..... STATE.....



How to take a load off your mind



The "load" we're talking about is *deadweight*— excess poundage in your equipment—that costs you money every time you move it.

IF you're worried because your equipment costs more to operate—or costs more to ship—because it is heavier than it need be, here is a way to overcome the difficulty . . . turn deadweight into dollars by building lighter with U·S·S High Strength Steels.

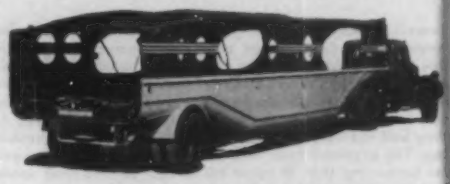
With these famous *"steels that do more"*—stronger, tougher, more durable U·S·S COR-TEN and U·S·S MAN-TEN—you can reduce the weight of many kinds of equipment. And you can do it at practically no increase in cost over that of heavier carbon steel construction.

It's a fact. First applied to reduce the weight of freight cars and streamlined trains, these steels have also lifted the costly drag of deadweight off buses, trucks, trailers and street cars. They have even been used in hot water heating tanks, hydraulic lifting jacks, refrigerators, shop pallets and tote boxes. The variety of products made lighter and better by their use runs the gamut from filing-cabinet drawer runners to earth-moving equipment of gigantic size.

Remember, the tougher your competition gets, the more costly deadweight becomes. Every pound of weight you can save in your product means fewer pounds of metal to buy . . . fewer pounds to move . . . fewer pounds to ship. Our engineers pioneered high strength steels. They have had 14 years' experience applying U·S·S High Strength Steels to all kinds of equipment. They will be glad to assist you any time you're ready to tackle this problem of weight reduction. Let them tell you how readily these superior steels can be applied to make *your* product lighter, how readily they fabricate and how little they cost to use.

23% lighter in weight when built of U·S·S MAN-TEN, with no loss of strength

In the production of these gas cylinders, U·S·S MAN-TEN not only cuts weight with no loss of strength, but simplifies and speeds up fabrication, improves resistance to impact and to atmospheric corrosion and reduces shipping costs.



U·S·S COR-TEN keeps costs at rock bottom, cuts weight 31%

In this trailer body, built just as strong as before, 2¼ tons of COR-TEN do the work of 3½ tons of carbon steel. One ton of steel saved in every unit makes it possible to build 44% more units—13 bodies instead of 9—from the same total tonnage of steel. If you want to cut costs—cut weight.

U·S·S COR-TEN cuts weight 18%, cuts material costs 10.8%, cuts shipping costs 16%

Used in this domestic water heater in place of carbon steel, COR-TEN reduces weight 42 lbs. per unit, saves 35 cents on steel costs, reduces freight charges 72 cents—total savings per tank of $1.07. Even on static equipment like this, lighter weight construction with COR-TEN offers important economies by reducing cost of shipment from steel mill to producing plant, from plant to market.

3½ tons of deadweight trimmed off here

By replacing rolled steel members with almost-twice-as-strong U·S·S COR-TEN, the weight of this self-contained paving unit was reduced from 16 tons to 12½ tons. Though 7,000 lbs. lighter, this equipment is now stronger than before, has greater wear resistance, higher resistance to atmospheric corrosion, will better withstand shock, impact and fatigue.

Light in weight, but tough and durable

Mixer blades, blade liners, front drum head, rear cone, and drum wrapper of this cement mixer are made from U·S·S MAN-TEN to increase resistance to abrasion and to obtain high strength with least weight.

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
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UNITED STATES STEEL

SUCCESS STORY —IN *Magnesium*

Bus Heater Fans Die Cast In Perfect Balance—More Durably And At Lower Costs.

Evans Products Company, large manufacturers of bus heaters recently changed over the so-important fans for this type of equipment from non-metallic substances to magnesium by LITEMETAL DICAST. Exhaustive tests proved that these fans die cast of magnesium were not only more durable and lower in cost than the other types formerly used *but* they had the very great advantage of not requiring balancing. The previous type non-metallic fans bore an expense for balancing that in some cases approached their manufacturing cost; whereas, these die cast magnesium fans have their balance built into the die. This is just another case illustrating the facilitating and economizing of production through the use of die castings made from light metal alloys.

Die casting with these new light metal alloys offers to manufacturers greater opportunities to lower production costs and the weight of their products. Also, these metals allow more freedom of design and offer greater scope in carrying out the designers' ideas. In addition, these die castings save many man-hours of finishing time.

Die Castings of magnesium or aluminum may offer you solutions to many of your cost and production problems.

LITEMETAL DICAST, INC. is an organization of specialists—men thoroughly experienced in the casting and machining of magnesium and aluminum alloys—the new metals of structural design.

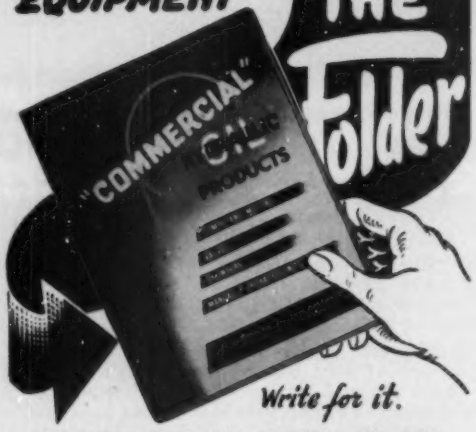
Write today for literature and case histories of Litemetal Dicasting.

Quick action on inquiries.

LITEMETAL DICAST Inc.
A DIVISION OF HAYES INDUSTRIES
1921 WILDWOOD AVE. · JACKSON, MICHIGAN
PLANT AND EXECUTIVE OFFICES

FOR HYDRAULIC EQUIPMENT

This is THE Folder



Write for it.

DO YOU USE OR EXPECT TO USE HYDRAULIC OIL. PUMPS, MOTORS, VALVES, CYLINDERS ? ? THEN YOU SHOULD HAVE THIS FOLDER.

THE COMMERCIAL SHEARING & STAMPING CO.
P. O. BOX 719 YOUNGSTOWN 1, OHIO

Manufactured To Your Specifications

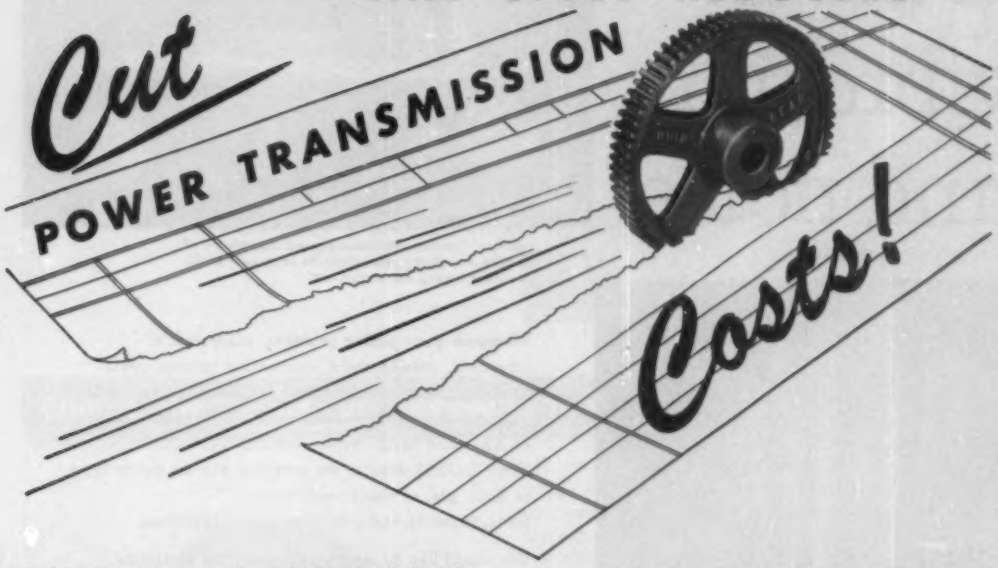
Here, with excellent facilities and years of experience, we are prepared to manufacture molded parts of natural or synthetic, sponge or solid rubber, to customer specifications.

Rubber couplings, pads, gaskets, valve discs, cushions and blocks are but a few of the many items regularly manufactured. Write outlining your requirements or, better still, send us your blueprints.

DUTCH BRAND

VAN CLEEF BROS. INC.
Manufacturers Rubber Products Est. 1910
CHICAGO 19, U. S. A.

OHIO STOCK GEARS AND SPEED REDUCERS



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IN CANADA, *Montreal, Quebec, John Braidwood & Sons, Ltd.

*Stocks Carried. ESTABLISHED 1915

THE OHIO GEAR COMPANY

1325 EAST 179th STREET • CLEVELAND 10, OHIO

Power transmission cost is one place you can make solid savings. Use Ohio Stock Gears and Speed Reducers for the machines you build or maintain and you win these three cost-cutting advantages:

1. They *are* stock, saving the extra cost of "specials."
2. No waiting. Deliveries are "right off the shelf".
3. Replacements are quicker, cost less and eliminate expensive down time.

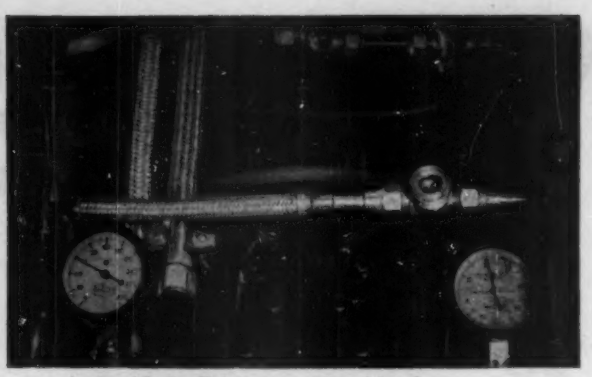
Ohio Stock Gears are available in spur, helical, bevel, worm and worm gear types, in pitch diameters from 24 to 6 and in mitre type from 24 to 4.

Ohio Stock Reducers include ratios from 10-1 to 3200-1; single reduction capacities from 1/6 HP to 10 HP; double reduction capacities from 25 inch pounds to 6000 inch pounds torque.

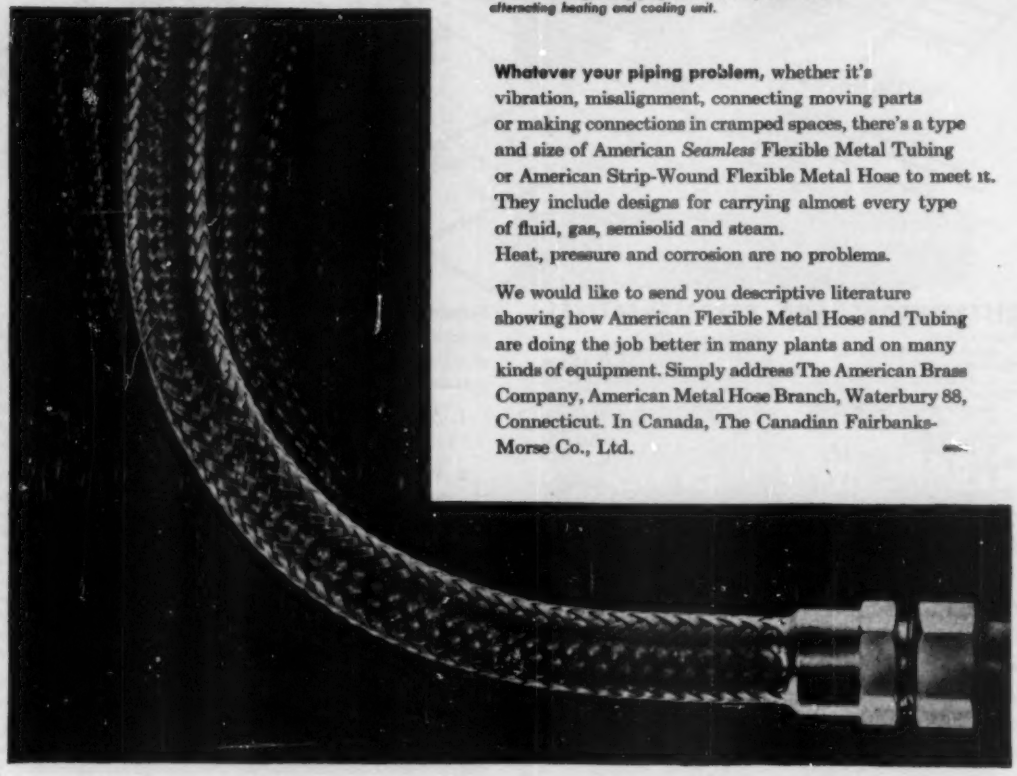
Put these Ohio Stock Gear and Speed Reducer advantages to work on the machines you design and operate. Our nearest distributor will be glad to help you.

OHIO GEARS

to block vibration and noise



American Vibration Eliminators prevent transmission of vibration through the piping from the compressor of this alternating heating and cooling unit.



Whatever your piping problem, whether it's vibration, misalignment, connecting moving parts or making connections in cramped spaces, there's a type and size of American *Seamless* Flexible Metal Tubing or American Strip-Wound Flexible Metal Hose to meet it. They include designs for carrying almost every type of fluid, gas, semisolid and steam.
Heat, pressure and corrosion are no problems.

We would like to send you descriptive literature showing how American Flexible Metal Hose and Tubing are doing the job better in many plants and on many kinds of equipment. Simply address The American Brass Company, American Metal Hose Branch, Waterbury 88, Connecticut. In Canada, The Canadian Fairbanks-Morse Co., Ltd.

wherever connectors must move

ANACONDA
American
FLEXIBLE METAL HOSE AND TUBING

How to save *most* in assembly

SKIPS TAPPING, AVOIDS INSERTS, MAKES STRONGER FASTENINGS

Timely Toys, Inc. chose P-K Type Z Self-tapping Screws to fasten the metal base plate and mechanism to the polystyrene shell of this popular Turnabout toy car. Screws are driven rapidly with a power driver, and the strong, rigid fastening withstands shock and abuse. Manufacturer says, "No other method would give us the production speed wanted without breakage." Find out how you can make similar savings in time, avoid breakage, and add strength.

Choose the "*short cut*" fastening method

When you make fastenings with Self-tapping Screws, you simply drive them in plain, untapped holes. You avoid tapping for machine screws, inserts in plastics and other assembly-slowing operations like nut-running and riveting. Stripped threads, tap breakage, and parts spoilage are no longer a problem, and your assembly is stronger. But choosing this common sense *method* is only the first step.

Let P-K* fit the fastener to the job

TYPE Z
(also made with Phillips Head)

Only Parker-Kalon offers a complete line of Self-tapping Screws. P-K fits the right fastener to your needs, not your needs to a fastener. Another reason why P-K can help you save most is their 35 year experience as Self-tapping Screw specialists. P-K applications number more than a million, many with savings up to 50% and over.

Find out what you can save. Call in a P-K Assembly Engineer, or send assembly details for recommendation.

Remember, the actual cost of screws depends, never on price, *always* on performance. Specify P-K Self-tapping Screws, and you'll see why the makers of so many of the nation's best-known products say—IF IT'S P-K . . . IT'S O. K.!

Parker-Kalon Corporation, 200 Varick St., New York 14, N. Y. Sold everywhere through accredited Distributors.

*Trade Marks Reg. U. S. Pat. Off.

NEED SPECIAL SMALL SIZE PHILLIPS HEAD SCREWS?

P-K Type A or Z, in No. 0 or 00 diameter, with a No. 0 Phillips Recess, can be made to order, quantity permitting.

P-K TRADE MARK

The Original

PARKER-KALON* SELF-TAPPING SCREWS

A TYPE AND SIZE FOR EVERY METAL AND PLASTIC ASSEMBLY

A Cambridge One Direction Weave Belt, chain driven and fitted with stiffening rods, carries raw wool through the continuous drying operation. The wide-open mesh permits free passage of the warm, dry air for fast, clean drying.

with *Cambridge* WIRE BELTS

Cambridge Wire Belts are efficient workers in your field. They serve in heat, cold, corrosive and wet processes; through packaging and assembly operations—moving quickly or slowly at constant or varying speeds. Wherever a material can be processed during movement, a Cambridge belt can, and does, save time, money and floor space.

Cambridge offers you a modern engineering staff with experience in your field and skilled workmen to produce the right belt in the correct mesh and weave, metal or alloy to perform your operation better . . . for longer.

Consult your Cambridge representative—look under "Belting, Mechanical" in your Classified Telephone Directory or write direct.

FREE BOOK—Famous throughout industry as the most valuable reference work on belts and conveyor systems. Write for your free copy . . .

Cambridge Wire Cloth Co.

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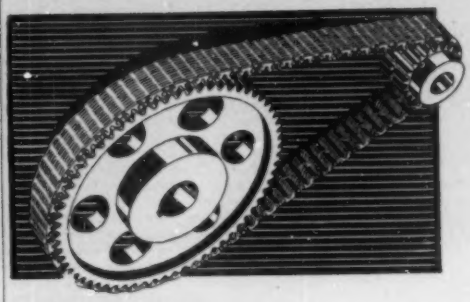
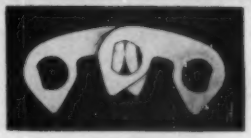
Wire cloth in rolls | Also specialized wire fabrications

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

RAMSEY *Silent* CHAIN DRIVES





See how it ROLLS . . .

Note that the two pins engaging the links of the chain have rolling surfaces similar to those of rollers in a roller bearing in contact with their raceways. This patented Ramsey feature assures a free-moving, frictionless joint with least possible lubrication.

. . . permitting you to design for better lubrication

A Ramsey Silent Chain Drive requires only a minimum amount of lubricant, in fact, no more than would be given a frictionless bearing. This advantageous feature means not only less attention and less opportunity for lubricant to be thrown out, but provides the designer with a drive that can be used on applications where there must be utmost cleanliness, such as in food and textile equipment where contamination and spoilage cannot be tolerated.

There are many other features in Ramsey Chain Drives which will appeal strongly to product engineers. It will be to your advantage to investigate *NOW*.

SEND FOR A COPY of the 60-page, fully illustrated Ramsey Application Manual. It will show you how easily you can improve your product by improving the drive.

RAMSEY CHAIN CO., INC.
5051 BROADWAY • ALBANY, N. Y.

This is *IT* for Stainless Steel Fastenings

Over 7,000 Varieties and Sizes of Stainless Fastenings IN STOCK

Virtually every standard stainless fastening you might require is on hand in our stock bins and listed in the big, 80-page Anti-Corrosive Reference Catalog . . . called by many the "Bible of the Stainless Steel Fastening Industry."

Fingertip Index Makes Items Easy to Find; Prices Are Figured INSTANTLY

Separate sections are devoted to stainless steel machine screws, nuts, caps and bolts, wood and sheet metal screws, rivets, set screws, washers, pins and nails. In addition, each page shows list prices for all items and a quantity discount chart which makes cost estimating a simple task!

Supplementary List of Hard-to-Get Items IN STOCK; Special Alloy Section

Thousands of odd sizes and varieties in stock are found in the supplementary stock list. In addition, special sections are devoted to type 316 and other special alloys. Other items can be obtained rapidly through our special order service.

If YOU Use Stainless Steel Fastenings This Catalogue is a MUST for Your Files!

Whatever application you have for stainless fastenings, this comprehensive and authoritative reference will save you time, effort and expense. Send for your copy NOW!

Anti-Corrosive Metal Products Co., Inc. SINCE 1927

Manufacturers of STAINLESS STEEL FASTENINGS

CASTLETON ON HUDSON NEW YORK

Simply Fill Out the Coupon Below and Mail *Today* for Your FREE Copy of This Catalog

ANTI-CORROSIVE METAL PRODUCTS CO., INC.
Castleton-on-Hudson, New York

Please rush my FREE copy of your 80-page reference catalog on stainless steel fastenings.

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Title_____ Firm_____

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WELCO MOTOR Rolls 55 ton Billets

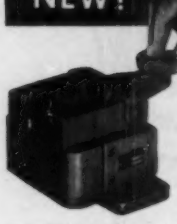
Once again Welco Special Torque Motors demonstrate that they begin where standard motors quit. 90 of these power laden monsters in a bank drive the steel mill rolls that handle 55 ton billets. Built for Hydropress, Inc., they are the first of their kind made in the U. S. A. They are totally enclosed, fin cooled, A.C. three phase, 50 cycle and operate at 150 R.P.M.

Starting from scratch Welco is prepared to design and build motors to your specification. Please write us your requirements.

THE B. A. WESCHE ELECTRIC CO.
1620-1628 VINE ST., CINCINNATI 10, OHIO

NEW! DIFFERENT!

TWO NEW VALVES FOR *Effortless* CONTROL OF AIR CYLINDERS!



TYPE NH (above)—A new hand-operated, four-way, directional air control valve. Sizes ⅛" and ¼". ⅜" lever motion.

TYPE NF (right)—A new foot-operated, four way, directional air control valve. Sizes ⅛" and ¼". With or without pedal guard.

HERE is the newest thing in air valves for operating single or double acting air cylinders! Built for *hand or foot* operation, these instant-acting valves provide fast, effortless control comparable to an electric valve—*at minimum cost.*

DISC TYPE; SELF-LAPPING—Metal-to-metal seat. Air tight. Packless.

PILOT CONTROLLED; PISTON OPERATED—Only light touch required; air does the work—shifts the main valve.

PRECISION ENGINEERED—Simple, compact, self-contained; rugged! Try one today. *Ask for bulletins.*

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Diefendorf gives every order expert, undivided attention at every step of manufacture—whether the order is large or small—whether for a complete new installation or for a few replacement gears. Diefendorf is equipped to make gears of all types and all sizes—all materials. Specification orders only.

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DIEFENDORF GEARS

when you want **THIS** →

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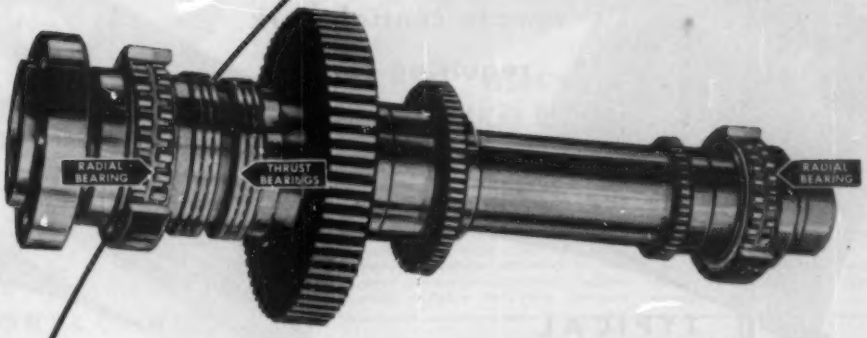


. . . look into the SKF spindle design that provides from 100% to 500% GREATER SPINDLE RIGIDITY

When the going's hard and the cuts are heavy, here's how to say "Goodbye" to chatter. Equip your machine tools with the SKF Spindle which yields under load *as low as one fifth that of ordinary designs.*

RADIAL RIGIDITY IS PROVIDED BY THE DOUBLE ROW CYLINDRICAL ROLLER BEARINGS

Why?

Because the outer ring roller path offers no resistance to axial movement. Therefore, the outer ring is mounted with a press fit in the housing to increase rigidity.

Because a tight fit on the tapered spindle seat eliminates creep and gives rigid support to the inner ring.

Because internal clearance of the bearing is removed by expanding the tapered bore inner ring on the spindle.

Because the cylindrical rollers are lapped to closest tolerance, so that correct load distribution within the bearing is always assured.

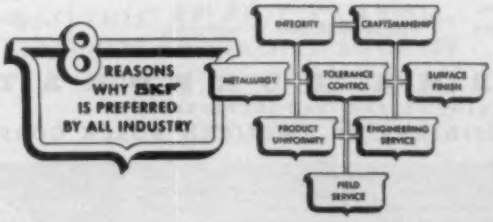
Because the roller paths are ground and honed.

Because the great number of rollers and their staggered arrangement insure efficient load distribution and virtual elimination of bridging effect.

AXIAL RIGIDITY IS PROVIDED BY THE BALL THRUST BEARINGS

SKF Catalog No. 272-A tells how this spindle design can be adapted to your particular requirements. SKF Industries, Inc., Phila. 32, Pa.

7041



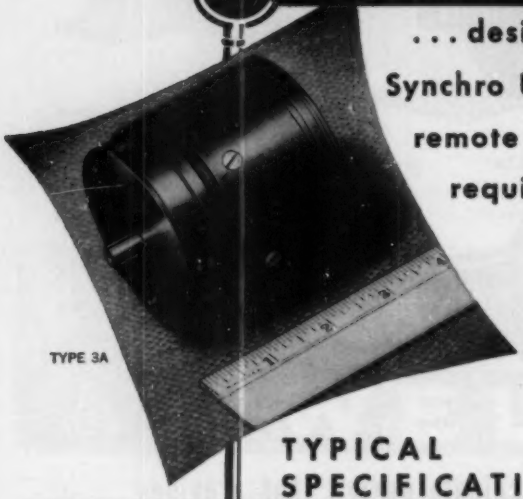
SKF
BALL AND ROLLER BEARINGS

Pioneers of the Deep Groove Ball Bearing—Spherical Roller Bearing—Self-Aligning Ball Bearing

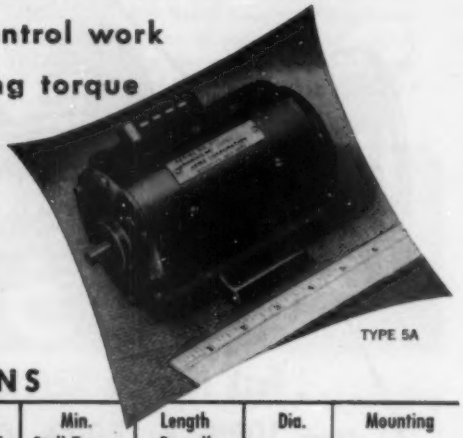
Announcing 2

ARMA STEP MOTORS

. . . designed to replace a Synchro Unit and a servo motor in remote control work requiring torque



TYPE 3A



TYPE 5A

TYPICAL SPECIFICATIONS

	Dwg. No.	Voltage	Weight (Approx.)	Min. Stall Torque	Length Overall	Dia.	Mounting
Type 3A	715774-1	115 V d.c.	3 lb.	22 oz. in.	3-15/32"	3 in.	Flange
Type 5A	51224-1	115 V d.c.	10 lb.	55 oz. in.	6-11/16"	3⅝ in	Bracket type Base

FEATURES

• *Convenient mounting* • *Accurately ground, true running shaft extensions* • *Self-contained terminal blocks* • *Low power consumption* • *Conservative electrical design, low temperature rise, large creepage distances and air gaps*

COMPARED WITH ALTERNATING CURRENT SYNCHRO UNIT

- Much greater torque available than from same size A.C. Synchros.
- Both are used primarily for the transmission of data from one point to another. Both serve as remote indicators or repeaters.

Step Motor Booklet Just Printed Gives Complete Details
ASK FOR A COPY

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254 36th STREET, BROOKLYN 32, N. Y.
SUBSIDIARY OF AMERICAN BOSCH CORPORATION

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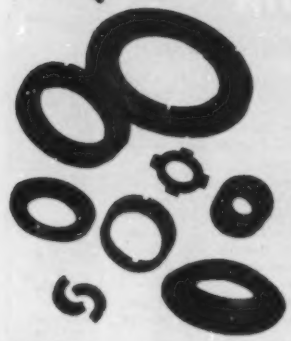
QUALITY ARMA INSTRUMENTS PRECISION

STACKPOLE

CARBON • GRAPHITE • MOLDED METAL

Engineering News

No. 5



NEW! SEAL RINGS FOR CORROSIVE CHEMICALS

Recent developments in Stackpole carbon-graphite shaft seal rings and washers include types that are highly effective in the pumping of acids and other corrosive chemicals. In addition, Stackpole offers unsurpassed facilities for engineering suitable grades for practically any requirement. Many grades are available and can be produced to suitable tolerances and specifically designed for operation against plates of bronze, brass, aluminum or other materials. Friction is greatly reduced and such unfavorable factors as tamping, packing and tightening are eliminated. Nor is there any danger of shaft abrasion when these composition seals are used!

Practically every application presents a different set of problems. Hence, Stackpole engineers welcome full details of your requirement on which their recommendations and sample seals or washers can be based. You be the judge!

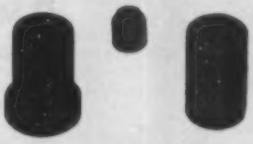
HERE'S SIMPLIFIED ULTRA-CRITICAL RESISTANCE OR VOLTAGE CONTROL

Continuously adjustable rheostats formed of piles of Stackpole carbon and graphite discs provide the ideal means of varying either resistance or voltage with maximum precision and smoothness simply by applying pressure to the piles. Applications range from generating equipment voltage regulators to line, speed and pressure regulators, continuously variable rheostats, pressure indicators and others. Recent Stackpole developments include a carbon-graphite mix which enables a single pile of only 39 discs to develop 150 ohms at 1 ounce pressure and 20 ohms at 80 ounces, for a sewing machine control previously involving two piles totaling 150 discs.

If you have a possible application, why not submit details to Stackpole for recommendation?

DASH POT PLUNGERS WITHOUT LIQUID LUBRICANTS

Few applications better illustrate the versatility of Stackpole graphite than its use for dash pot plungers—for the simple reason that the static friction of graphite against the smooth metal cylinder is not much greater than that of the sliding friction. No liquid lubricants which would be adversely affected by temperature changes are required. Thus the damping coefficient of a graphite plunger is determined almost entirely by the viscosity of the air itself. Stackpole facilities in this specialized field provide for the design and production of eminently satisfactory plungers for practically any dash pot need.



LOW-FRICTION BEARINGS OF CARBON AND GRAPHITE

The use of self-lubricating bearings of carbon and graphite composition holds interesting possibilities for a wide variety of modern equipment. Units can be molded rather inexpensively to suitable tolerances and both the composition of the bearing mix and the shape of the finished piece can readily be designed for maximum efficiency. Beyond this, the graphite greatly decreases both friction and wear by coating *both* surfaces. Stackpole has achieved considerable success in this field and would like to tackle additional bearing problems where carbon and graphite compositions may hold the answers.

Why not send full details of your application for recommendation by Stackpole engineers?

GET THIS HELPFUL CARBON-GRAPHITE SPECIALTIES BOOKLET

This 44-page, profusely illustrated book has been prepared to help you evaluate the possibilities of components of molded carbon, graphite and powdered metal composition in a broad range of modern equipment. Included are details on Stackpole tube anodes, battery carbons, ground rods, contacts, carbon piles, chemical carbons, friction segments, clutch rings, brazing and welding carbons, carbon molds and dies and many other products.

STACKPOLE CARBON COMPANY, St. Marys, Pa.

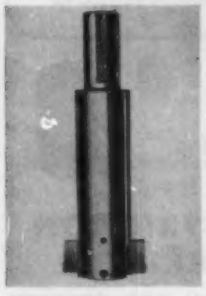
Designers!

If you have either of these assembly problems—

Write for our helpful booklet

1 Make it tight against vibration

An air impeller, for example. The fasteners are under *continual* vibration. A famous manufacturer of air-moving equipment (name on request) uses Bristol's Multiple-Spline Socket Set Screws because the multiple-spline socket permits tightening much further than possible with any other screw.



2 Make it easy to adjust

Boring bars, for example, where the cutting blade is adjusted by turning a screw. A well-known tool manufacturer (name on request) uses Bristol's Multiple-Spline Socket Set Screws because the tight set is easily broken by a flick of the wrench—with no spoiled screws.

Multiple-Spline and Hex Socket Screws . . . Cap and Set

BRISTOL'S
SOCKET SCREWS

Only BRISTOL gives you the right Socket Screw for every application

SEND FOR FREE SAMPLE AND BOOKLET, USING COUPON

THE BRISTOL COMPANY,
Mill Supply Division
121 Bristol Road, Waterbury 91, Conn.

Please send free sample of Bristol's Multiple-Spline Screw and bulletin showing applications to: Screw Sizes.....

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COMPANY.....

ADDRESS.....

CITY.....STATE.....

"Walking Away" WITH **96 BLOCKS**

All in the Day's Work for this **WISCONSIN POWERED UNIT**

Wisconsin-powered Lewis-Shepard fork truck, made by Lewis-Shepard Products, Inc., Watertown, Mass.

Handling heavy loads of concrete blocks with a fork truck calls for husky, dependable power . . . the kind delivered by the Wisconsin Heavy-Duty Air-Cooled Engine that "teams up" with this Lewis-Shepard unit. The net result is MORE WORK with LESS MAN HOURS and *minimum maintenance costs.*

Regardless of the field or application, you'll find Wisconsin Engines enthusiastically endorsed because of such features as thrust-absorbing Tapered Roller Bearings at both ends of the crankshaft . . . high-tension, rotary-type OUTSIDE Magneto with Impulse Coupling for quick any-season starting and running, plus trouble-free Air-Cooling.

4-cycle, single-cylinder, 2-cylinder, and V-type, 4-cylinder models, 3 to 30 hp. Specify WISCONSIN POWER for your equipment.

Single Cylinder 3 to 9 hp.

2-Cylinder 7 to 13 hp.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

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design basic parts for quantity production

more economically and quickly

THIS practical book covers the design of basic parts for quantity production by die casting, sand casting, screw machine, stamping, die forging, hot and cold heading and plastic molding. Along with full explanations of the various high-production processes, you get many specific rules, amply illustrated to show their practical applications for designing products that lend themselves to rapid and economical mass production.

HANDBOOK ON DESIGNING for QUANTITY PRODUCTION

Prepared and Edited by HERBERT CHASE

517 pages • 351 illustrations • $5.00

NOW you can avoid the necessity for redesign. Not only will you be able to form the original design quicker, but you can be sure to make it more suitable to economical production in large quantities. Use the book once for an invaluable design pointer on materials . . . for exact design considerations . . . or for one of the straight-forward rules to follow in designing basic parts for the different quantity production processes. Use it once, and then decide whether this book will remain right at your fingertips for instant reference.

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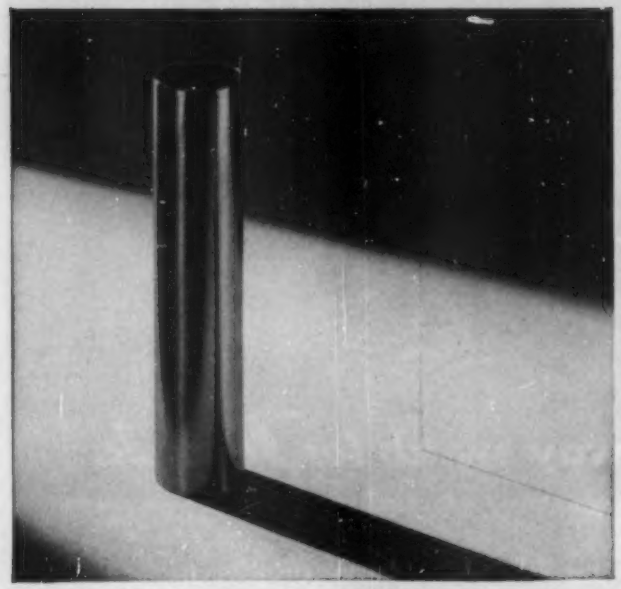
Can You See Two Tubes?



● There were actually *two* tubes in this unretouched photograph. One at the right was so fine—less than the diameter of a human hair!—that the screen in the printing plate almost eliminated it. The other is a Superior 5/8" O.D. tube.

Between these two sizes Superior makes tubing in all practical metals, alloys, forms, finishes, and tolerances.

Between these two sizes Superior is superior for know-how, facilities, metallurgy and technology in tubing.

There are 55 Superior Distributors in the U. S. and Canada. You can obtain excellent help, technical assistance, and advice from the one nearest you . . . and can probably obtain just the tubing you need from his adequate warehouse stock.

If you do not know your Superior distributor write directly to us for immediate attention to your tubing problems or tubing needs. Ask for Bulletin 31. Superior Tube Company, 2012 Germantown Ave., Norristown, Pennsylvania.

Superior's Physical Laboratory where tubing samples from every order are tested to make certain that their mechanical characteristics meet the customer's specification. Metallurgical conformity is insured by analysis in other laboratories.

One of the pickling rooms used to clean and pickle tubing. Stainless steels are often used for their appearance value as well as their resistance to corrosion and high temperature. For this reason pickling is more carefully controlled for Stainless steels than for other materials.

Partial view of the dies required for cold drawing and sinking of Superior specialty tubing. Our know-how in die design helps make Superior tubing superior.

Which Is The Better For Your Product . . .

SEAMLESS . . . ? The finest tubes that can be made. In all O.D.'s from 1½" O.D. and lower. Excellent for forming, bending, machining, etc. carbon, alloy, stainless, non-ferrous and glass sealing alloys.

Or WELDRAWN* . . . ? Welded and drawn from bright annealed, cold rolled strip. Economical. Available in stainless, non-ferrous and glass sealing alloys, but not in as wide a range of sizes as seamless.

Superior

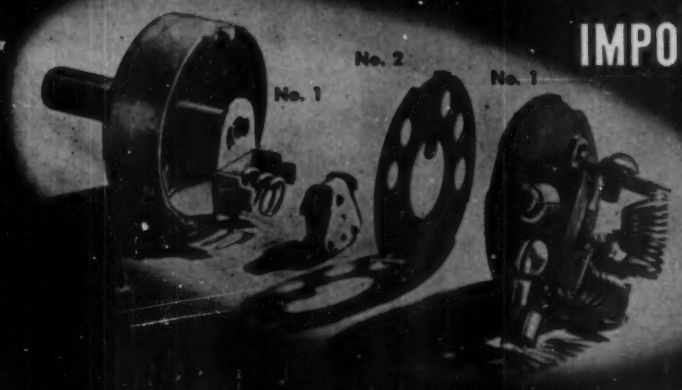
THE BIG NAME IN SMALL TUBING

All analyses .010" to ¾" O.D.
Certain analyses (.035" max. wall) Up to 1¼" O.D.

**Reg. U. S. Trademark—Superior Tube Company • West Coast: PACIFIC TUBE COMPANY, 5710 Smithway St., Los Angeles 22, Cal. • ANgelus 2-2151*

LAMINATED INSUROK BY RICHARDSON . . .

DOES IMPORTANT JOBS



. . . on a five way switch for Nash

In making a five way switch for the famous Nash Weather Eye Conditioned Air System, the Douglas Manufacturing Division, Bronson, Mich., needed three parts made of plastic insulation material that embodied a variety of characteristics. Richardson's Laminated INSUROK, in two different grades, was the answer.

One paper-base grade of Laminated INSUROK met all requirements for two of the parts because of its low moisture absorption, high strength, rigidity, dielectric strength, ease of fabrication and low cost. Another grade, with a fabric base, met special requirements for physical strength for the third part.

Two grades of INSUROK, in combination with metal components, resulted in a five way switch that will operate smoothly over long years of trouble-free use.

Perhaps Richardson's diverse materials of either Molded or Laminated plastic, standard or special, can solve a manufacturing problem for you.

INSUROK by RICHARDSON
Dependable names in plastics
INSUROK - Registered Trade Mark

The RICHARDSON COMPANY
GENERAL OFFICES: LOCKLAND, OHIO FOUNDED IN 1858
Sales Headquarters: MELROSE PARK, ILLINOIS
2793 LAKE STREET

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Fighting Death

ON THE HIGHWAYS

Telechron Timing Motors Help Reduce Driving Hazards

The careless driver is not solely to blame for the daily accident headlines. The driver whose vision or reactions are poor is another grave threat to safety on the nation's highways.

To keep the traffic accident rate to a minimum, the American Automobile Association has since 1936 conducted an intensive program of driver testing and training. Numerous testing devices — for color vision, finger reaction, foot reaction, etc. — are employed, not only to rate a driver's ability but to impress on him the necessity for "defensive driving" to guard against the other fellow's faults.

And since the appliances used to test human reactions must be accurate to a split-second, they are actuated by Telechron Timing Motors. *Instantly, constantly synchronous*, these famous motors respond with accurate, dependable performance — every time!

How's YOUR Timing?

If the control or recording of variables is your problem, very likely a standard Telechron Motor is your answer. A Telechron application engineer, backed by the broadest experience in the field, can help you decide that. For greatest savings in time and money, consult him as *early* as possible in your planning. Meanwhile, send the coupon for quick facts. TELECHRON INC. A General Electric Affiliate.

Telechron®

ALL TELECHRON TIMING MOTORS ARE

INSTANTLY...CONSTANTLY SYNCHRONOUS

TELECHRON INC.
10 Union Street
Ashland, Massachusetts

Please send me information on sizes and types of Telechron Synchronous Motors. My possible application is:

Instruments	☐	Communications Equipment	☐
Timers	☐	Other (please fill in)	
Electric Appliances	☐	.....	
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Need "POWER DRIVEN" Brushes That Can Take It?

This Manufacturer Did!

For the reconditioning of metal drums, the Gold Cooperage Company of Newark, N. J. uses a "Deco" automatic cleaning machine made by the Drum Equipment Company. The machine eliminated slow, costly hand power-brushing . . . but it requires brushes that will remove dirt, paint and rust without damaging drums . . . brushes that can "take it" eight hours a day, five days a week. Several companies submitted brushes for use with the machine, but once again, Pittsburgh's skilled brush engineers came up with the brush found to be best.

"PITTSBURGH" can solve your Brush Problems too!

In the complete Pittsburgh line are brushes of all types (including wheels, sections and assemblies), readily available for your use.

Or you may have what seems to be a complicated brush problem. If so, you can count on Pittsburgh ingenuity to design special brushes for the most unusual jobs. Time and time again, Pittsburgh has supplied the answer for leading firms in almost every industry . . . glass, steel and plastics . . . rubber, paper, automobile and dozens more. Write or call for information, or for a consultation with a Pittsburgh engineering representative. No obligation. Just phone or write PITTSBURGH PLATE GLASS COMPANY, *Brush Div.*, Dept. W-2, 3221 Frederick Avenue, Baltimore 29, Maryland.

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BRUSHES

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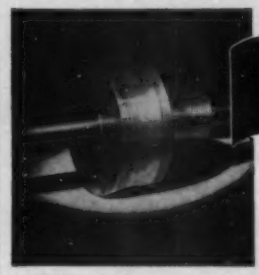
PITTSBURGH PLATE GLASS COMPANY

HILLIARD *Clutches*

FOR POWER CONTROL DESIGNS

HILLIARD SINGLE REVOLUTION CLUTCH

Unequalled for accurate control of intermittent machine operations — cutting, punching, and packaging. Gives closer tolerances to cut-off, stamping, shearing, and similar machines. Completely automatic; manual, mechanical, or electrical control.



HILLIARD OVER-RUNNING CLUTCH

Hilliard Over-Running Clutches and Couplings are automatic in operation. They are unexcelled for automatic two-speed drives, dual drives, stand-by drives, and for allowing machinery to "coast" after drive stops. Excellent as fixed or infinitely adjustable ratchets.

HILLIARD SLIP CLUTCH

A reliable series of spring-loaded slip clutches and couplings. Rugged construction with ample friction surface for heavy-duty use. Outstanding for preventing overloads and shocks; for starting heavy loads; as tension drag brakes; for reeling and winding operations; and many other uses.

Hilliard's Engineering Department is ready to assist you in designing installations and in selecting the correct clutch or coupling.
Write today — 3 Hilliard Clutch Bulletins with design information. Free on request.

Clutch Makers for over 40 years

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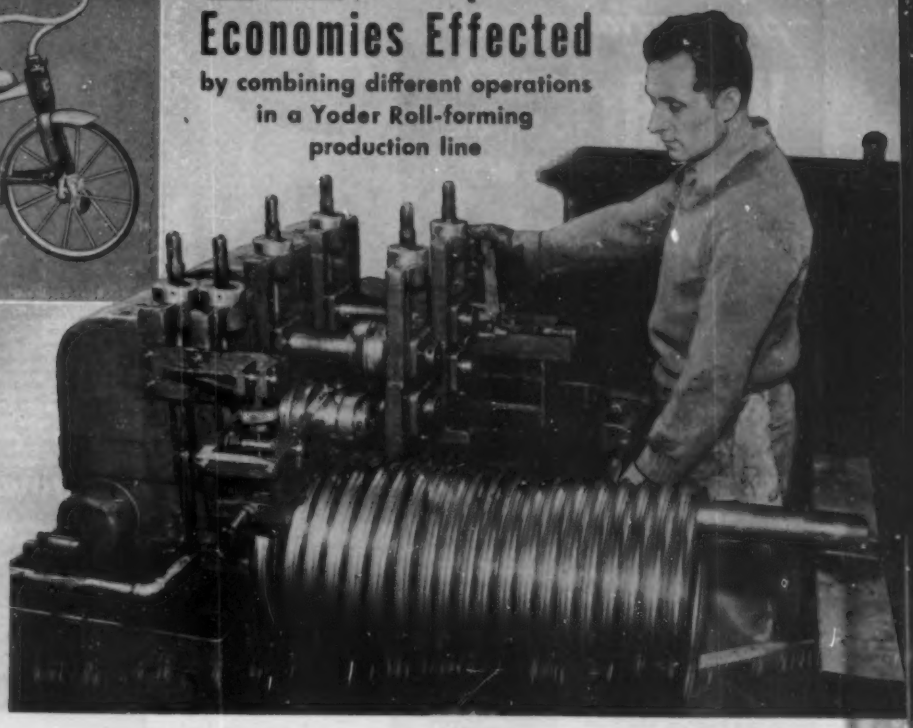
101 W. Fourth St., Elmira, N. Y.

OFFICES IN PRINCIPAL CITIES

*12 Examples of Economies Effected

by combining different operations in a Yoder Roll-forming production line



*NO. 6

Flat Strip Continuously formed and Coiled into Wheel Rims

The forming of wheel rims and rings for many purposes, can be done continuously, in a single passage through a Yoder cold roll forming machine equipped with a suitable coiling device. The coils may simultaneously be cut to length, coming out as individual rings, of almost any thickness, profile design, and diameter.

Many other operations can be performed in Yoder production lines, such as combining different metals, inserting paper, felt or rubber, injecting adhesives or viscous fluids, embossing, notching, perforating, seam or spot welding, etc.

Flat rolled metal up to ¼" thick, of almost any width, can be cold formed into structurals, mouldings, panels, tubes and other hollow sections.

Production upwards of 30,000 feet per day is obtainable, usually with only one operator, employing flat strip in coils or cut lengths.

This invests Cold Roll-Forming with infinite possibilities for drastic cost reductions in the mass production of structurals, mouldings and other components for buildings of all types, automobiles and other vehicles, furniture and fixtures, household appliances, toys, bicycles, etc.

Yoder engineers are at your service in designing roll forming production lines to meet individual needs. Literature, recommendations and estimates for the asking.

THE YODER COMPANY

5524 Walworth Avenue • Cleveland 2, Ohio

Complete Production Lines

- ★ COLD-ROLL-FORMING and auxiliary machinery
- ★ GANG SLITTING LINES for Coils and Sheets
- ★ PIPE and TUBE MILLS—cold forming and welding

ENGINEERING YODER MANUFACTURING

A NEW way to cut production costs!

VLIER Automatic TORQUE THUMB SCREWS

★ NOTHING TO WEAR OUT

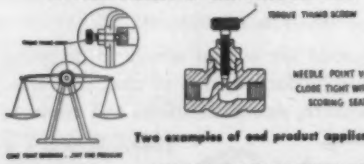
★ GUARANTEED PRODUCT UNIFORMITY

★ HOLDING PRESSURES CONSTANT UNDER ALL CONDITIONS

VLIER torque thumb screws are economical and unique tools designed to replace "home made" devices used by many manufacturers to support work in jigs and fixtures. When the proper torque thumb screw for the job is used, it is *impossible* to over-tighten and cause inaccurate drilling and milling due to warping of the work piece... results in additional savings of up to 80% in fixture rework costs!

VLIER torque thumb screws operate with a spring and ball-check system in the head. Specified spring tensions, which are pre-set at the factory, prevent tightening the screw beyond a pre-determined pressure. Screws with adjustable spring pressures are also available. All threads are national coarse class #1 fit for fast finger turning and to prevent jamming by grinding compounds — with substantial savings in set-up time. Other threads are available on request. Write today for information on complete VLIER line.

A WIDE VARIETY OF END PRODUCT USES



Two examples of end product applications

TYPICAL USERS OF VLIER PRODUCTS INCLUDE:

Allis-Chalmers Mfg. Co., Bendix Aviation Corp., Chrysler Corp., Ford Motor Co., General Electric Co., General Motors Corp., Lockheed Aircraft Corp.

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VLIER MANUFACTURING CO.

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DIVISIONS: EMC—ELECTRIC MOTOR CORP.
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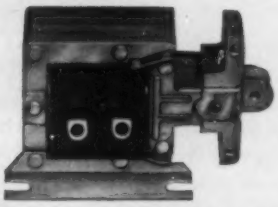

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For full engineering data, write Dept. N04.

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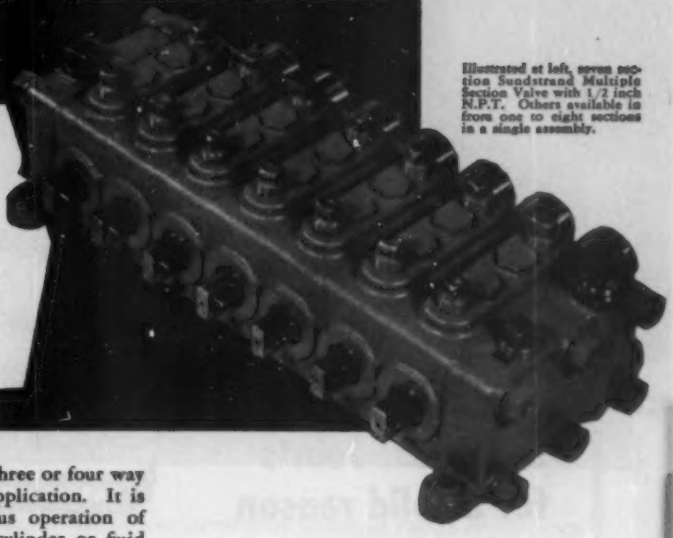
When You Need Positive Control...

Use This New SUNDSTRAND Multiple Section Valve For Series Application



Illustrated at left, seven section Sundstrand Multiple Section Valve with 1/2 inch N.P.T. Others available in from one to eight sections in a single assembly.

Illustrated is a new Sundstrand three or four way Multiple Section Valve for series application. It is manually controlled for simultaneous operation of more than one actuated member (cylinder or fluid motor) from a single oil power source or pump, provided the total accumulated load on all actuated members does not exceed the relief valve setting.

These valves are made up of individual sections for control of each actuated member and may be furnished in up to eight controls in a single assembly. Sundstrand Multiple Section Valves are compact and can be conveniently placed for control of moving members from one station. They are made up of heavy close grained cast iron body sections and have ample mounting lugs. The stem for each section is sealed against oil leakage as well as infiltration of dirt or foreign material that might impair operation.

Has Built-In Relief and Check Valve

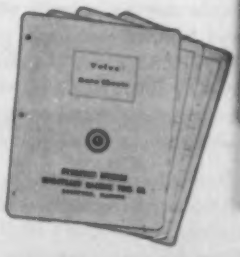
Overload control is provided by a built-in adjustable relief valve. In addition, two check valves in each section maintain positive positioning of actuated member and prevents losing control of the load.

Uses for Sundstrand Multiple Section Series Valves

Simple oil power hydraulic control can be easily applied to equipment such as dredging equipment, road machinery, excavating machines, snow removal machines, farm tractors, industrial tractors, well digging equipment and similar types of machinery.

Get Complete Data

This engineering data sheet provides complete dimensions, mounting information and capacities. Write for your copy today. Ask for bulletin No. P-52.



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FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS

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all use BLOOD BROTHERS Universal Joints for a solid reason

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From simple joints for shafts turned by hand wheels — to finely balanced precision propeller shafts — road building equipment requires universal joints of almost every type. Many of them take a high-speed, power-packed beating on giant trucks . . . tractors . . . and complex paving machines.

But be they big or small, where you find universals on road building equipment, you'll usually find BLOOD BROTHERS' name. The reason is simple — and solid. BLOOD BROTHERS Universal Joints are engineered and built to deliver what the job requires — with a wide margin to spare — through years of use.

Whether its road building machinery or another line — if you use universals, you may find it advantageous to consult with BLOOD BROTHERS' engineering staff. Write for catalog and information.

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A Division of Standard Steel Spring Co.
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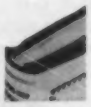
BARBER-COLMAN COMPANY ROCKFORD ILLINOIS

PRECISION DIE MADE — LOWEST POSSIBLE COST
DAYTON ROGERS MFG. CO.
Minneapolis 7, Minnesota

How to estimate the time any machining job will take



Whether a job involves drilling, boring, tapping, threading, grinding—or any other operation—this manual tells you exactly what to consider in estimating job-time. It covers every step—from setting up the job, to tearing it down—giving reasonable time values for each, based on actual experience.

MACHINE-SHOP ESTIMATING
BY
W. A. NORDHOFF

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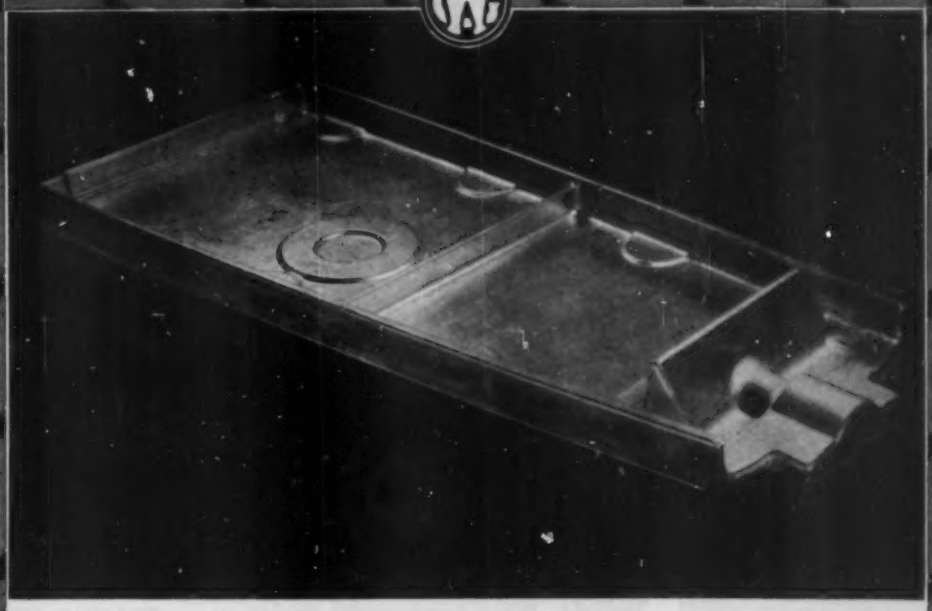

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For hammer or press die forgings of aluminum, magnesium or steel, Wyman-Gordon engineers are ready to serve you—there is no substitute for Wyman-Gordon experience.

Standard of the Industry for More Than Sixty Years

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In addition R-B-M General Purpose Relays are used on X-Ray apparatus, permanent wave machines, wire recorders, automotive radio telephone communication equipment, vending machines, coin operated phonographs and many other applications.

What is your relay problem?

Write Dept. C-4 today for Bulletin 570

R-B-M DIVISION ESSEX WIRE CORP.

Logansport, Indiana

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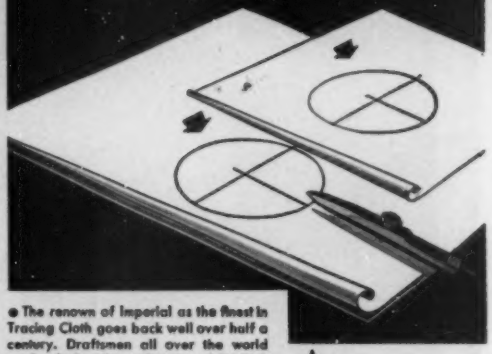

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Refrigerators used to hate children!

The Problem: Children and grownups would bump into refrigerators with their toys and packages and chip refrigerator coatings. Manufacturers got complaints.

The Solution: Industrial Finish Engineers developed a special finish that has extreme flexibility, so that when the refrigerator is banged, the finish bends with the metal. Because of it, manufacturers have all but eliminated customer complaints about the finish on their refrigerators.

Problem: At high airplane speeds, the atmospheric dust used to ruin the finish on airplanes.

Solution: Industrial Finish Engineers developed a finish of agate hardness, smooth enough to eliminate shock waves at high speeds—durable enough to withstand blasts of dust.

Problem: To find a finish for lipstick containers that would not be damaged every time milady took the top off.

Solution: Industrial Finish Engineers worked up a special finish that withstands constant friction, and perspiration. Containers keep their new look longer.

Problem: To find a way to keep the finish on door handles and other door hardware from wearing off.

Solution: Industrial Finish Engineers developed a finish that resists abrasion and perspiration from hands—isn't damaged by weather.

Let Industrial Finish Engineering help reduce your customer complaints!

Here are a few of the ways Industrial Finish Engineering can improve a product.

Other manufacturers report cuts in operating expenses, more sales appeal—thanks to Industrial Finish Engineering.

Learn what it can do for your product. Consult an Industrial Finish Engineer today.

For the Finish Industry has technical ability to make finishes equal to the purpose for which each product is bought. Remember, most of your customers *start buying with the finish in mind.*

The better the finish—The better the buy!

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Robertshaw

SINGLE UNIT

time,

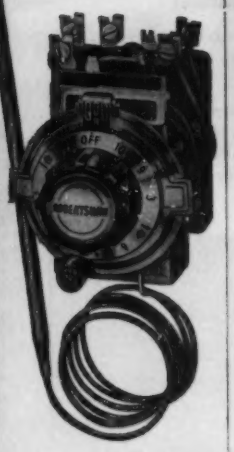
temperature

and motor

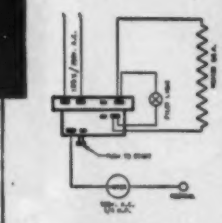
CONTROL for

LAUNDRY

DRYERS



H-15



1 Set temperature.
2 Push starting button to energize heater and motor.
3 When temperature is reached, heater is automatically disconnected and motor continues to run.
4 After cooling approximately 20°F., motor cuts off automatically.

Combines heating and timing controls in a single unit. Handles both motor and electrical heating circuits. Amount of moisture and weight of clothes scientifically determine length of time dryer operates to automatically produce degree of dryness desired by operator. Control cuts heat switch when correct internal temperature is reached, but motor continues to run until all stored heat in drying chamber has been utilized.

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that means tighter piping—better product appearance

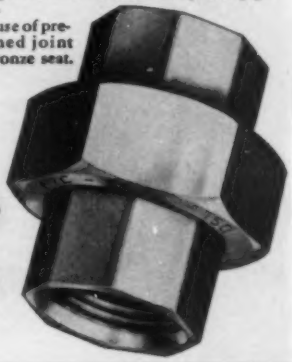
PIC is an attractive, machine-finished union that adds to the appearance of your product.

PIC is faster to install for ends are flat-sided to speed tightening with either pipe or open-ended wrench.

PIC is completely protected from rust and corrosion by zinc-plating even on threads.

PIC has tough non-porous ends of extra-heavy steel pipe coupling stock.

PIC stays tight because of precision-machined joint surfaces and bronze seat.



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Find out whether YOU are making use of the cost-cutting, product-improving development in Sealing Materials!

Take the LATEST ADVANCEMENTS in sealing materials, add FEL-PRO ENGINEERING to adapt them to the specific demands made upon the gaskets used in your products and you have a combination that can MAKE A WORLD OF DIFFERENCE!

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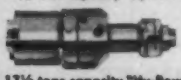
"Hy-Power" Hydraulic Pressure Generator

7½ tons capacity "Hy-Power" cylinder.

10 tons capacity "Hy-Power" cylinder.

12½ tons capacity "Hy-Power" cylinder.



17½ tons capacity "Hy-Power" cylinder.

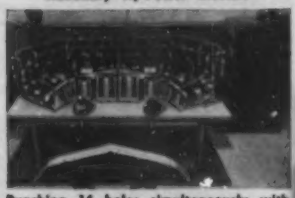
25 tons capacity "Hy-Power" cylinder.

35 tons capacity "Hy-Power" cylinder.

50 tons capacity "Hy-Power" cylinder.

Fabricating steel floor gratings with portable "Hy-Power" Riveter.

Riveting cylindrical furnace section with stationary "Hy-Power" Riveter.



Punching 16 holes simultaneously with multiple polyangle punching set-up.

Punching automobile radiator grill base bars with "Hy-Power" units.

Heavy duty multiple punching machine for automobile frame side rails.

HERE is an opportunity for design engineers and tool makers interested in securing simple, easy to use, "cost reducing" production equipment for a minimum investment! HANNIFIN "HY-POWER" HYDRAULICS has brought about an entirely new concept of the high speeds and extreme forces that can be developed hydraulically with small, compact, automatic work units. "Hy-Power" Hydraulic Pressure Generators give you up to 5,000 p.s.i. pressure at your finger-tips under instant, safe, automatic control. When applied through one or more "Hy-Power" Hydraulic Cylinders, almost any desired force is available for performing a wide variety of riveting, punching, pressing, shearing, forming, multiple riveting, multiple punching, and similar operations. Hannifin engineers will be glad to cooperate with you in supplying "Hy-Power" pressure generators and cylinders for machines of your own design or in supplying complete "Hy-Power" work units. Send for information.

NEW BULLETIN

• 28 pages of useful engineering and application data on "HY-POWER" HYDRAULICS. Lists specifications and dimensions for standard portable riveters, pressure generators, and cylinders — 7½ to 100 tons capacity. Send for your copy.

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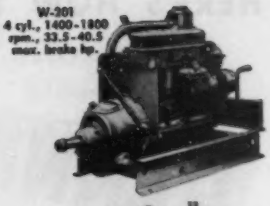
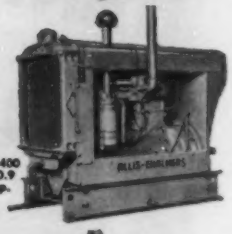
Figures in model designations represent cu. in. piston displacement. Each size engine available in either open or enclosed style.

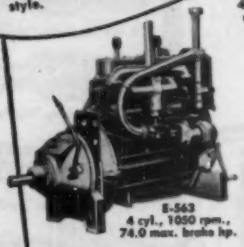
B-125
4 cyl., 1500-1900 rpm.,
24.5-28.0 max. brake hp.



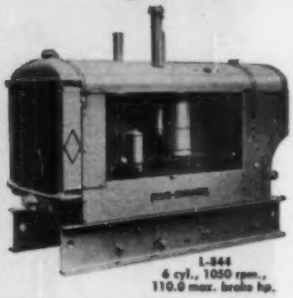
W-201
4 cyl., 1400-1800 rpm., 33.5-40.5 max. brake hp.



U-318
4 cyl., 1200-1400 rpm., 45.0-50.9 max. brake hp.



B-563
4 cyl., 1050 rpm.,
74.0 max. brake hp.



L-844
6 cyl., 1050 rpm.,
110.0 max. brake hp.

Let our engineers work with you in selecting power to match your product.

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PRESS ON . . .
quick, positive assembly.

CLAMP SHUT. . .
360° closure supports greater thrust loads.

OPEN . . . PULL OFF. . .
fast, easy removal simplifies service and repair.

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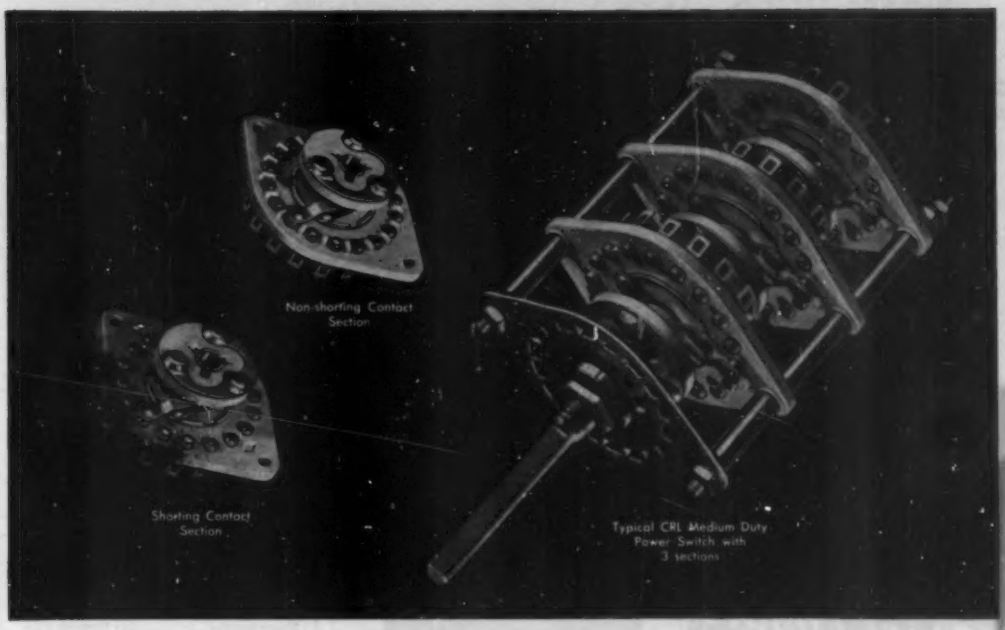
THE BINGHAM-HERBRAND CORPORATION, FREMONT, OHIO

NOW YOU CAN GET A CUSTOM-BUILT MEDIUM-DUTY POWER SWITCH



Centralab medium-duty power switches give you wide choice of high-capacity standard and custom combinations for big variety of industrial uses

YES, CRL's Medium Duty Power Switches are made to meet your individual needs . . . single, two or three poles . . . 18 contacts per section . . . up to 20 sections per shaft. Contacts and collector rings of coin silver, mounted on Grade L5 Steatite, compounded and produced right in our own plant . . . backed up by 20 years of ceramic manufacturing experience.

These switches are designed for R.F. or 7½ amp. 110-115 V. application. The combination of rugged construction — coin silver contacting members, plus the high insulation resistance of Grade L5 Steatite, means trouble-free performance in x-ray, lab-test equipment, high voltage transmitters and other electronic gear.

For top-performing medium duty power switches, built for life-time service — in standard or custom built models ask about CRL's "torture tested" power switch line. Our engineers will be glad to assist you.

STANDARD MEDIUM DUTY SWITCH SIZES

Part No. Shorting	Part No. Non-Shorting	Total Poles	Positions	Total Sections	Poles per Section
JV9000	JV9001	1	2-17	1	1
JV9002	JV9003	3	2- 5	1	3
JV9004	JV9005	2	2-17	2	1
JV9006	JV9007	6	2- 5	2	3
JV9008	JV9009	3	2-17	3	1
JV9010	JV9011	9	2- 5	3	3
JV9012	JV9013	4	2-17	4	1
JV9014	JV9015	12	2- 5	4	3
JV9016	JV9017	5	2-17	5	1
JV9018	JV9019	15	2- 5	5	3
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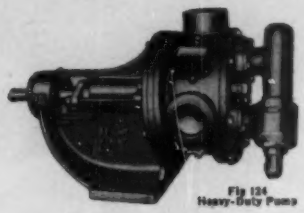

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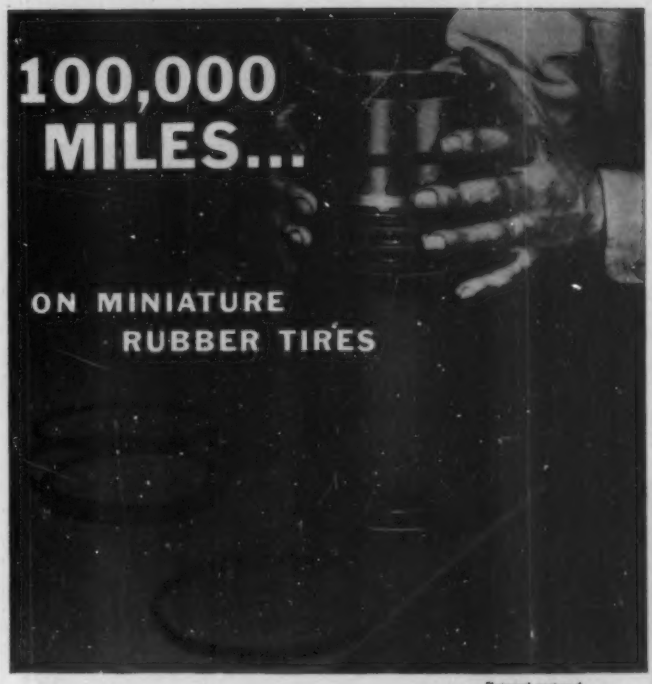

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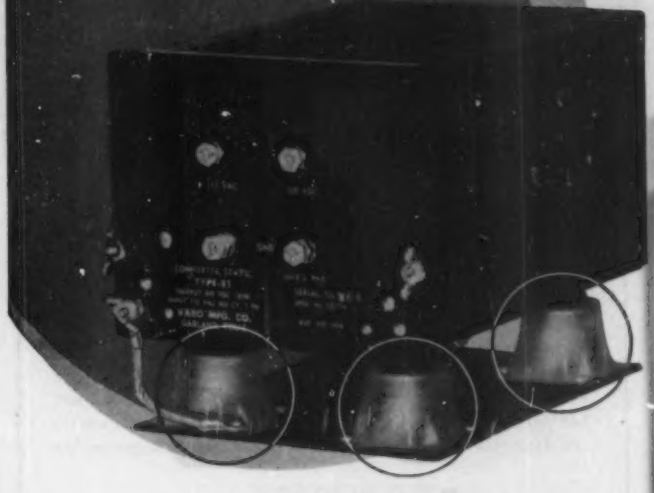

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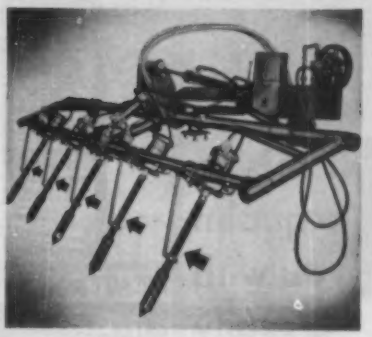

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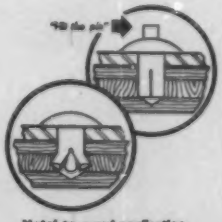

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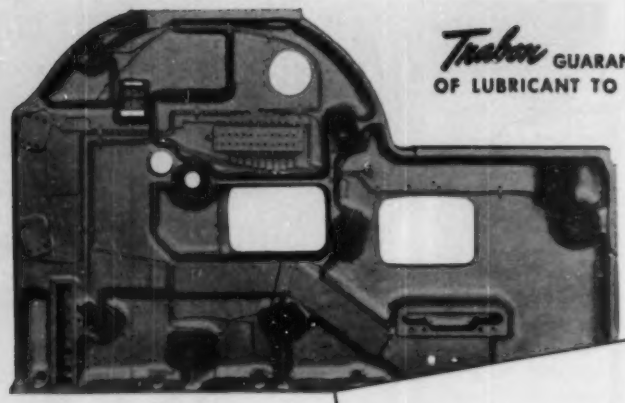

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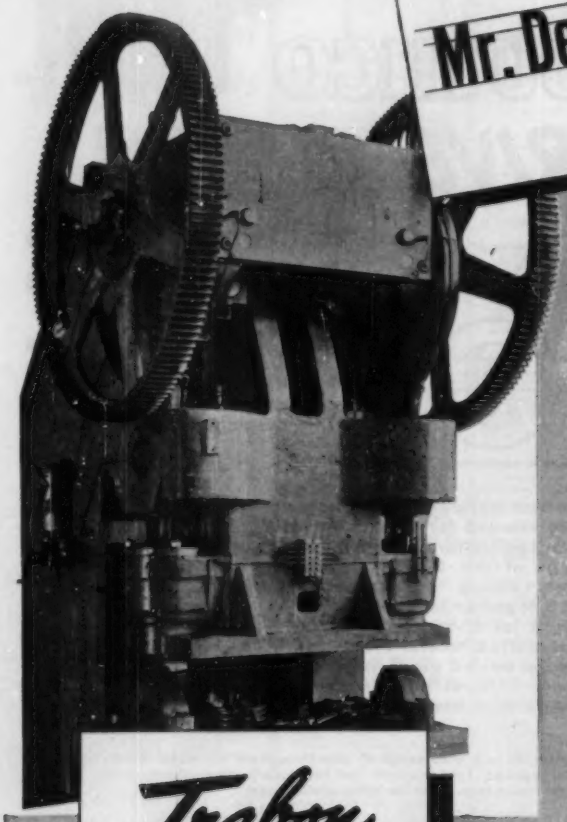

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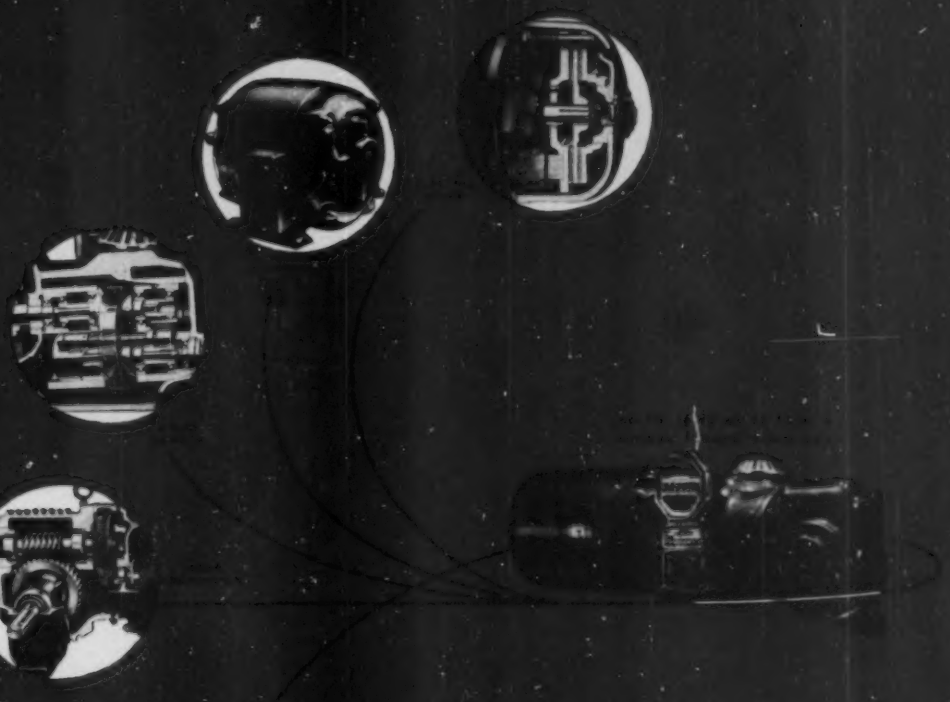

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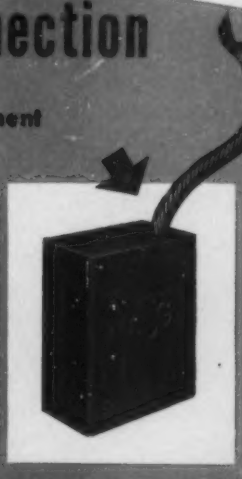

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